UNITED STATES PATENT APPLICATION FOR:

METHODS AND APPARATUS FOR CEMENTING DRILL STRINGS IN PLACE FOR ONE PASS DRILLING AND COMPLETION OF OIL AND GAS WELLS

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METHODS AND APPARATUS FOR CEMENTING DRILL STRINGS IN PLACE FOR ONE PASS DRILLING AND COMPLETION OF OIL AND GAS WELLS

PRIORITY FROM U.S. PATENT APPLICATIONS

The present application is a continuation-in-part (C.I.P.) application of co-pending U.S. Patent Application Serial No. 10/189,570, filed July 6, 2002, that is entitled "Installation of One-Way Valve After Removal of Retrievable Drill Bit to Complete Oil and Gas Wells", which is fully incorporated herein by reference.

U.S. Patent Application Serial No. 10/189,570 is a continuation-in-part (C.I.P.) application of co-pending U.S. Patent Application Serial No. 10/162,302, filed June 4, 2002, that is entitled "Closed-Loop Conveyance Systems for Well Servicing", which is fully incorporated herein by reference.

U.S. Patent Application Serial No. 10/162,302 is a continuation-in-part (C.I.P.) application of U.S. Patent Application Serial No. 09/487,197, filed January 19, 2000, that is entitled "Closed-Loop System to Complete Oil and Gas Wells", now U.S. Patent No. 6,397,946, that issued on June 4, 2002, which is fully incorporated herein by reference.

U.S. Patent Application Serial No. 09/487,197 was corrected by a Certificate of Correction, which was "Signed and Sealed" on the date of October 1, 2002, to be a continuation-in-part (C.I.P.) of U.S. Patent Application Serial No. 09/295,808, filed April 20, 1999, that is entitled "One Pass Drilling and Completion of Extended Reach Lateral

Wellbores with Drill Bit Attached to Drill String to Produce Hydrocarbons from Offshore Platforms", now U.S. Patent No. 6,263,987, that issued on July 24, 2001, which is fully incorporated herein by reference.

U.S. Patent Application Serial No. 09/295,808 is a continuation-in-part (C.I.P.) of U.S. Patent Application Serial No. 08/708,396, filed September 3, 1996, that is entitled "Method and Apparatus for Cementing Drill Strings in Place for One Pass Drilling and Completion of Oil and Gas Wells", now U.S. Patent No. 5,894,897, that issued on April 20, 1999, which is fully incorporated herein by reference.

U.S. Patent Application Serial No. 08/708,396 is a continuation-in-part (C.I.P.) of U.S. Patent Application Serial No. 08/323,152, filed October 14, 1994, that is entitled "Method and Apparatus for Cementing Drill Strings in Place for One Pass Drilling and Completion of Oil and Gas Wells", now U.S. Patent No. 5,551,521, that issued on September 3, 1996, which is fully incorporated herein by reference.

Applicant claims priority from and the benefit of the above six U.S. Patent Applications having Serial Nos. 10/189,570, 10/162,302, 09/487,197, 09/295,808, 08/708,396, and 08/323,152.

RELATED APPLICATIONS

The present application relates to U.S. Patent Application Serial No. 09/375,479, filed August 16, 1999, that is entitled "Smart Shuttles to Complete Oil and Gas Wells", now U.S. Patent No. 6,189,621, that issued on

February 20, 2001, which is fully incorporated herein by reference.

The present application further relates to PCT Application Serial No. PCT/US00/22095, filed August 9, 2000, that is entitled "Smart Shuttles to Complete Oil and Gas Wells", which is fully incorporated herein by reference. This PCT Application corresponds to U.S. Patent Application Serial No. 09/375,479. This application has also been published elsewhere as WO 01/12946 A1 (on 2/22/2001); EP 1210498 A1 (on 6/5/2002); CA 2382171 AA (on 2/22/2001); and AU 0067676 A5 (on 3/13/2001).

The present application also relates to U.S. Patent Application Serial No. 09/294,077, filed April 18, 1999, that is entitled "One Pass Drilling and Completion of Wellbores with Drill Bit Attached to Drill String to Make Cased Wellbores to Produce Hydrocarbons", now U.S. Patent No. 6,158,531, that issued on December 12, 2000, which is fully incorporated herein by reference.

RELATED U.S. DISCLOSURE DOCUMENTS

This application further relates to disclosure in U.S. Disclosure Document No. 362582, filed on September 30, 1994, that is entitled in part 'RE: Draft of U.S. Patent Application Entitled "Method and Apparatus for Cementing Drill Strings in Place for One Pass Drilling and Completion of Oil and Gas Wells"', an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 445686, filed on October 11, 1998,

having the title that reads exactly as follows: 'RE: -Invention Disclosure- entitled "William Banning Vail III, October 10, 1998"', an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 451292, filed on February 10, 1999, that is entitled in part 'RE: -Invention Disclosure- "Method and Apparatus to Guide Direction of Rotary Drill Bit" dated February 9, 1999"', an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 452648 filed on March 5, 1999 that is entitled in part 'RE: "-Invention Disclosure- February 28, 1999 One-Trip-Down-Drilling Inventions Entirely Owned by William Banning Vail III"', an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 455731 filed on May 2, 1999 that is entitled in part 'RE: -INVENTION DISCLOSURE- entitled "Summary of One-Trip-Down-Drilling Inventions"', an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 459470 filed on July 20, 1999 that is entitled in part 'RE: -INVENTION DISCLOSURE ENTITLED "Different Methods and Apparatus to ''Pump-down''.... "', an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 462818 filed on September 23, 1999 that is entitled in part "Directional Drilling of Oil and Gas

Wells Provided by Downhole Modulation of Mud Flow", an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 465344 filed on November 19, 1999 that is entitled in part "Smart Cricket Repeaters in Drilling Fluids for Wellbore Communications While Drilling Oil and Gas Wells", an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 474370 filed on May 16, 2000 that is entitled in part "Casing Drilling with Standard MWD/LWD ....Having Releasable Standard Sized Drill Bit", an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 475584 filed on June 13, 2000 that is entitled in part "Lower Portion of Standard LWD/MWD Rotary Drill String with Rotary Steering System and Rotary Drill Bit Latched into ID of Larger Casing Having Undercutter to Drill Oil and Gas Wells Whereby the Lower Portion is Retrieved upon Completion of the Wellbore", an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 521399 filed on November 12, 2002 that is entitled in part "Additional Methods and Apparatus for Cementing Drill Strings in Place for One Pass Drilling and Completion of Oil and Gas Wells", an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 521690 filed on November 14, 2002

that is entitled in part "More Methods and Apparatus for Cementing Drill Strings in Place for One Pass Drilling and Completion of Oil and Gas Wells", an entire copy of which is incorporated herein by reference.

This application further relates to disclosure in U.S. Disclosure Document No. 522547 filed on December 5, 2002 that is entitled in part "Pump Down Cement Float Valve Needing No Special Apparatus Within the Casing for Landing the Cement Float Valve", an entire copy of which is incorporated herein by reference.

Various references are referred to in the above defined U.S. Disclosure Documents. For the purposes herein, the term "reference cited in applicant's U.S. Disclosure Documents" shall mean those particular references that have been explicitly listed and/or defined in any of applicant's above listed U.S. Disclosure Documents and/or in the attachments filed with those U.S. Disclosure Documents. Applicant explicitly includes herein by reference entire copies of each and every "reference cited in applicant's U.S. Disclosure Documents". In particular, applicant includes herein by reference entire copies of each and every U.S. Patent cited in U.S. Disclosure Document No. 452648, including all its attachments, that was filed on March 5, 1999. To best knowledge of applicant, all copies of U.S. Patents that were ordered from commercial sources that were specified in the U.S. Disclosure Documents are in the possession of applicant at the time of the filing of the application herein.

Applications for U.S. Trademarks have been filed in the USPTO for several terms used in this application.
An application for the Trademark "Smart Shuttle™" was filed on February 14, 2001 that is Serial No. 76/213676, an entire

copy of which is incorporated herein by reference. The "Smart Shuttle™" is also called the "Well Locomotive™". An application for the Trademark "Well Locomotive™" was filed on February 20, 2001 that is Serial Number 76/218211, an entire copy of which is incorporated herein by reference. An application for the Trademark of "Downhole Rig" was filed on June 11, 2001 that is Serial Number 76/274726, an entire copy of which is incorporated herein by reference. An application for the Trademark "Universal Completion Device™" was filed on July 24, 2001 that is Serial Number 76/293175, an entire copy of which is incorporated herein by reference. An application for the Trademark "Downhole BOP" was filed on August 17, 2001 that is Serial Number 76/305201, an entire copy of which is incorporated herein by reference.

Accordingly, in view of the Trademark Applications, the term "smart shuttle" will be capitalized as "Smart Shuttle"; the term "well locomotive" will be capitalized as "Well Locomotive"; the term "universal completion device" will be capitalized as "Universal Completion Device"; and the term "downhole bop" will be capitalized as "Downhole BOP".

BACKGROUND OF THE INVENTION

1. Field of Invention

The fundamental field of the invention relates to apparatus and methods of operation that substantially reduce the number of steps and the complexity to drill and complete oil and gas wells. Because of the extraordinary breadth of the fundamental field of the invention, there are many related separate fields of the invention.

Accordingly, the field of invention relates to apparatus that uses the steel drill string attached to a drilling bit during drilling operations used to drill oil and gas wells for a second purpose as the casing that is cemented in place during typical oil and gas well completions. The field of invention further relates to methods of operation of apparatus that provides for the efficient installation of a cemented steel cased well during one single pass down into the earth of the steel drill string. The field of invention further relates to methods of operation of the apparatus that uses the typical mud passages already present in a typical drill bit, including any watercourses in a "regular bit", or mud jets in a "jet bit", that allow mud to circulate during typical drilling operations for the second independent, and the distinctly separate, purpose of passing cement into the annulus between the casing and the well while cementing the drill string into place during one single drilling pass into the earth. The field of invention further relates to apparatus and methods of operation that provides the pumping of cement down the drill string, through the mud passages in the drill bit, and into the annulus between the formation and the drill string for the purpose of cementing the drill string and the drill bit into place during one single drilling pass into the formation. The field of invention further relates to a one-way cement valve and related devices installed near the drill bit of the drill string that allows the cement to set up efficiently while the drill string and drill bit are cemented into place during one single drilling pass into the formation.

The field of invention further relates to the use of a slurry material instead of cement to complete wells during the one pass drilling of oil and gas wells, where the term "slurry material" may be any one, or more, of at least the

following substances: cement, gravel, water, "cement clinker", a "cement and copolymer mixture", a "blast furnace slag mixture", and/or any mixture thereof; or any known substance that flows under sufficient pressure. The field of invention further relates to the use of slurry materials for the following type of generic well completions: open-hole well completions; typical cemented well completions having perforated casings; gravel well completions having perforated casings; and for any other related well completions. The field of invention also relates to using slurry materials to complete extended reach wellbores and extended reach lateral wellbores. The field of invention also relates to using slurry materials to complete extended reach wellbores and extended reach lateral wellbores from offshore platforms.

The field of the invention further relates to the use of retrievable instrumentation packages to perform LWD/MWD logging and directional drilling functions while the well is being drilled, which are particularly useful for the one pass drilling of oil and gas wells, and which are also useful for standard well completions, and which can also be retrieved by a wireline attached to a Smart Shuttle having retrieval apparatus or by other different retrieval means. The field of the invention further relates to the use of Smart Shuttles having retrieval apparatus that are capable of deploying and installing into pipes smart completion devices that are used to automatically complete oil and gas wells after the pipes are disposed in the wellbore, which are useful for one pass drilling and for standard cased well completions, and these pipes include the following: a drill pipe, a drill string, a casing, a casing string, tubing, a liner, a liner string, a steel pipe, a metallic pipe, or any other pipe used for the completion of oil and gas wells. The field of the invention further relates to Smart Shuttles that use internal pump

means to pump fluid from below the Smart Shuttle, to above it, to cause the Smart Shuttle to move within the pipe to conveniently install smart completion devices.

The field of invention disclosed herein also relates to using progressive cavity pumps and electrical submersible motors to make Smart Shuttles. The field of invention further relates to closed-loop systems used to complete oil and gas wells, where the term "to complete a well" means "to finish work on a well and bring it into productive status". In this field of the invention, a closed-loop system to complete an oil and gas well is an automated system under computer control that executes a sequence of programmed steps, but those steps depend in part upon information obtained from at least one downhole sensor that is communicated to the surface to optimize and/or change the steps executed by the computer to complete the well.

The field of invention further relates to a closed-loop system that executes the steps during at least one significant portion of the well completion process and the completed well is comprised of at least a borehole in a geological formation surrounding a pipe located within the borehole, and this pipe may be any one of the following: a metallic pipe; a casing string; a casing string with any retrievable drill bit removed from the wellbore; a casing string with any drilling apparatus removed from the wellbore; a casing string with any electrically operated drilling apparatus retrieved from the wellbore; a casing string with any bicenter bit removed from the wellbore; a steel pipe; an expandable pipe; an expandable pipe made from any material; an expandable metallic pipe; an expandable metallic pipe with any retrievable drill bit removed from the wellbore; an expandable metallic pipe with any drilling apparatus removed

from the wellbore; an expandable metallic pipe with any electrically operated drilling apparatus retrieved from the wellbore; an expandable metallic pipe with any bicenter bit removed from the wellbore; a plastic pipe; a fiberglass pipe; any type of composite pipe; any composite pipe that encapsulates insulated wires carrying electricity and/or any tubes containing hydraulic fluid; a composite pipe with any retrievable drill bit removed from the wellbore; a composite pipe with any drilling apparatus removed from the wellbore; a composite pipe with any electrically operated drilling apparatus retrieved from the wellbore; a composite pipe with any bicenter bit removed from the wellbore; a drill string; a drill string possessing a drill bit that remains attached to the end of the drill string after completing the wellbore; a drill string with any retrievable drill bit removed from the wellbore; a drill string with any drilling apparatus removed from the wellbore; a drill string with any electrically operated drilling apparatus retrieved from the wellbore; a drill string with any bicenter bit removed from the wellbore; a coiled tubing; a coiled tubing possessing a mud-motor drilling apparatus that remains attached to the coiled tubing after completing the wellbore; a coiled tubing left in place after any mud-motor drilling apparatus has been removed; a coiled tubing left in place after any electrically operated drilling apparatus has been retrieved from the wellbore; a liner made from any material; a liner with any retrievable drill bit removed from the wellbore; a liner with any liner drilling apparatus removed from the wellbore; a liner with any electrically operated drilling apparatus retrieved from the liner; a liner with any bicenter bit removed from the wellbore; any other pipe made of any material with any type of drilling apparatus removed from the pipe; or any other pipe made of any material with any type of drilling apparatus removed from the wellbore.

The field of invention further relates to a closed-loop system that executes the steps during at least one significant portion of the well completion process and the completed well is comprised of at least a borehole in a geological formation surrounding a pipe that may be accessed through other pipes including surface pipes, production lines, subsea production lines, etc.

Following the closed-loop well completion, the field of invention further relates to using well completion apparatus to monitor and/or control the production of hydrocarbons from within the wellbore.

The field of invention also relates to closed-loop systems to complete oil and gas wells that are useful for the one pass drilling and completion of oil and gas wells.

The field of the invention further relates to the closed-loop control of a tractor deployer that may also be used to complete an oil and gas well.

The invention further relates to the tractor deployer that is used to complete a well, perform production and maintenance services on a well, and to perform enhanced recovery services on a well.

The invention further relates to the tractor deployer that is connected to surface instrumentation by a substantially neutrally buoyant umbilical made from composite materials.

Yet further, the field of invention also relates to a method of drilling and completing a wellbore in a geological formation to produce hydrocarbons from a well comprising at

least the following four steps: drilling the well with a retrievable drill bit attached to a casing; removing the retrievable drill bit from the casing; pumping down a one-way valve into the casing with a well fluid; and using the one-way valve to cement the casing into the wellbore.

And finally, the field of invention relates to drilling and completing wellbores in geological formations with different types of pipes having a variety of retrievable drill bits that are completed with pump-down one-way valves.

2. Description of the Prior Art

From an historical perspective, completing oil and gas wells using rotary drilling techniques has in recent times comprised the following typical steps. With a pile driver or rotary rig, install any necessary conductor pipe on the surface for attachment of the blowout preventer and for mechanical support at the wellhead. Install and cement into place any surface casing necessary to prevent washouts and cave-ins near the surface, and to prevent the contamination of freshwater sands as directed by state and federal regulations. Choose the dimensions of the drill bit to result in the desired sized production well. Begin rotary drilling of the production well with a first drill bit. Simultaneously circulate drilling mud into the well while drilling. Drilling mud is circulated downhole to carry rock chips to the surface, to prevent blowouts, to prevent excessive mud loss into formation, to cool the bit, and to clean the bit. After the first bit wears out, pull the drill string out, change bits, lower the drill string into the well and continue drilling. It should be noted here that each "trip" of the drill bit typically requires many hours of rig

time to accomplish the disassembly and reassembly of the drill string, pipe segment by pipe segment.

Drill the production well using a succession of rotary drill bits attached to the drill string until the hole is drilled to its final depth. After the final depth is reached, pull out the drill string and its attached drill bit. Assemble and lower the production casing into the well while back filling each section of casing with mud as it enters the well to overcome the buoyancy effects of the air filled casing (caused by the presence of the float collar valve), to help avoid sticking problems with the casing, and to prevent the possible collapse of the casing due to accumulated build-up of hydrostatic pressure.

To "cure the cement under ambient hydrostatic conditions", typically execute a two plug cementing procedure involving a first Bottom Wiper Plug before and a second Top Wiper Plug behind the cement that also minimizes cement contamination problems comprised of the following individual steps. Introduce the Bottom Wiper Plug into the interior of the steel casing assembled in the well and pump down with cement that cleans the mud off the walls and separates the mud and cement. Introduce the Top Wiper Plug into the interior of the steel casing assembled into the well and pump down with water under pump pressure thereby forcing the cement through the float collar valve and any other one-way valves present. Allow the cement to cure.

SUMMARY OF THE INVENTION

The present invention allows for cementation of a drill string with attached drill bit into place during one single

drilling pass into a geological formation. The process of drilling the well and installing the casing becomes one single process that saves installation time and reduces costs during oil and gas well completion procedures. Apparatus and methods of operation of the apparatus are disclosed that use the typical mud passages already present in a typical rotary drill bit, including any watercourses in a "regular bit", or mud jets in a "jet bit", for the second independent purpose of passing cement into the annulus between the casing and the well while cementing the drill string in place. This is a crucial step that allows a "Typical Drilling Process" involving some 14 steps to be compressed into the "New Drilling Process" that involves only 7 separate steps as described in the Description of the Preferred Embodiments below. The New Drilling Process is now possible because of "Several Recent Changes in the Industry" also described in the Description of the Preferred Embodiments below. In addition, the New Drilling Process also requires new apparatus to properly allow the cement to cure under ambient hydrostatic conditions. That new apparatus includes a Latching Subassembly, a Latching Float Collar Valve Assembly, the Bottom Wiper Plug, and the Top Wiper Plug. Suitable methods of operation are disclosed for the use of the new apparatus.

Suitable apparatus and methods of operation are disclosed for drilling the wellbore with a rotary drill bit attached to a drill string, which possesses a stabilizer, that is cemented in place as the well casing by using a one-way cement valve during one drilling pass into a geological formation. Suitable apparatus and methods of operation are disclosed for drilling the wellbore with a rotary drill bit attached to a drill string, which possesses a stabilizer, which is also used to centralize the drill

string in the well during cementing operations. Suitable apparatus and methods of operation are also disclosed for drilling the wellbore with a rotary drill bit attached to a casing string, which possesses a stabilizer, that is also used to centralize the drill string in the well. A method is also provided for drilling and lining a wellbore comprising: drilling the wellbore using a drill string, the drill string having an earth removal member operatively connected thereto and a casing portion for lining the wellbore; stabilizing the drill string while drilling the wellbore; locating the casing portion within the wellbore; and maintaining the casing portion in a substantially centralized position in relation to a diameter of the wellbore.

Suitable methods and apparatus are disclosed for drilling the wellbore with a rotary drill bit attached to a drill string, which possesses a directional drilling means, that is cemented in place as the well casing by using a one-way cement valve during one drilling pass into a geological formation. Suitable methods and apparatus are also disclosed for drilling the wellbore with a rotary drill bit attached to a drill string that has means for selectively causing a drilling trajectory to change during drilling. A method is also provided for drilling and lining a wellbore comprising: drilling the wellbore using a drill string, the drill string having an earth removal member operatively connected thereto and a casing portion for lining the wellbore; selectively causing a drilling trajectory to change during the drilling; and lining the wellbore with the casing portion.

Suitable methods and apparatus are disclosed for drilling the wellbore with a rotary drill bit attached to a drill string, which possesses a geophysical parameter sensing

member, that is cemented in place as the well casing by using a one-way cement valve during one drilling pass into a geological formation. Suitable methods and apparatus are also disclosed for drilling the wellbore with a rotary drill bit attached to a drill string that has at least one geophysical parameter sensing member to measure at least one geophysical quantity from within the drill string. Apparatus is also provided for drilling a wellbore comprising: a drill string having a casing portion for lining the wellbore; and a drilling assembly operatively connected to the drill string and having an earth removal member and a geophysical parameter sensing member.

Suitable methods and apparatus are provided for drilling the wellbore with a rotary drill bit attached to a drill string that is encapsulated in place with a physically alterable bonding material as the well casing by using a one-way valve during one drilling pass into a geological formation. Suitable methods and apparatus are also provided for drilling the wellbore with a rotary drill bit attached to a drill string that is encapsulated with a physically alterable bonding material that is allowed to cure in the wellbore to make a cased wellbore. A method is also provided for lining a wellbore with a tubular comprising: drilling the wellbore using a drill string, the drill string having a casing portion; locating the casing portion within the wellbore; placing a physically alterable bonding material in an annulus formed between the casing portion and the wellbore; establishing a hydrostatic pressure condition in the wellbore; and allowing the bonding material to physically alter under the hydrostatic pressure condition.

Suitable methods and apparatus are provided for drilling the wellbore with a drill string having a rotary drill bit

attached to a drilling assembly which has a portion that is selectively removable from the wellbore before the drill string is cemented into place by using a one-way valve during one pass drilling into a geological formation. Suitable methods and apparatus are provided for drilling the wellbore with a drill string having a rotary drill bit attached to a drilling assembly which has a portion that is selectively removable from the wellbore before the drill string is cemented into place as the well casing. An apparatus is also provided for drilling a wellbore comprising: a drill string having a casing portion for lining the wellbore; and a drilling assembly operatively connected to the drill string and having an earth removal member; a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

Suitable methods and apparatus are provided for drilling the wellbore from an offshore platform with a rotary drill bit attached to a drill string and then cementing that drill string into place by using a one-way valve during one drilling pass into a geological formation. Suitable methods and apparatus are also provided for drilling the wellbore from an offshore platform with a rotary drill bit attached to a drill string which may be cemented into place or which may be retrieved from the wellbore prior to cementing operations. A method is also provided for drilling a borehole into a geological formation from an offshore platform using casing as at least a portion of the drill string and completing the well with the casing during one single drilling pass into the geological formation.

Methods are further disclosed wherein different types of slurry materials are used for well completion that include at least cement, gravel, water, a "cement clinker", and any

"blast furnace slag mixture". Methods are further disclosed using a slurry material to complete wells including at least the following: open-hole well completions; cemented well completions having a perforated casing; gravel well completions having perforated casings; extended reach wellbores; extended reach lateral wellbores; and extended reach lateral wellbores completed from offshore drilling platforms.

Involving the one pass drilling and completion of wellbores that is also useful for other well completion purposes, the present invention includes Smart Shuttles which are used to complete the oil and gas wells. Following drilling operations into a geological formation, a steel pipe is disposed in the wellbore. In the following, any pipe may be used, but an example of steel pipe is used in the following examples for the purposes of simplicity only. The steel pipe may be a standard casing installed into the wellbore using typical industry practices. Alternatively, the steel pipe may be a drill string attached to a rotary drill bit that is to remain in the wellbore following completion during so-called "one pass drilling operations". Further, the steel pipe may be a drill pipe from which has been removed a retrievable or retractable drill bit. Or, the steel pipe may be a coiled tubing having a mud motor drilling apparatus at its end. Using typical procedures in the industry, the well is "completed" by placing into the steel pipe various standard completion devices, some of which are conveyed into place with the drilling rig. Here, instead, Smart Shuttles are used to convey into the steel pipe various smart completion devices used to complete the oil and gas well. The Smart Shuttles are then used to install various smart completion devices. And the Smart Shuttles may be used to retrieve from the wellbore various smart completion

devices. Smart Shuttles may be attached to a wireline, coiled tubing, or to a wireline installed within coiled tubing, and such applications are called "tethered Smart Shuttles". Smart Shuttles may be robotically independent of the wireline, etc., provided that large amounts of power are not required for the completion device, and such devices are called "untethered shuttles". The smart completion devices are used in some cases to machine portions of the steel pipe. Completion substances, such as cement, gravel, etc. are introduced into the steel pipe using smart wiper plugs and Smart Shuttles as required. Smart Shuttles may be robotically and automatically controlled from the surface of the earth under computer control so that the completion of a particular oil and gas well proceeds automatically through a progression of steps. A wireline attached to a Smart Shuttle may be used to energize devices from the surface that consume large amounts of power. Pressure control at the surface is maintained by use of a suitable lubricator device that has been modified to have a Smart Shuttle chamber suitably accessible from the floor of the drilling rig. A particular Smart Shuttle of interest is a wireline conveyed Smart Shuttle that possesses an electrically operated internal pump that pumps fluid from below the shuttle to above the shuttle that causes the Smart Shuttle to pump itself down into the well. Suitable valves that open allow for the retrieval of the Smart Shuttle by pulling up on the wireline. Similar comments apply to coiled tubing conveyed Smart Shuttles. Using Smart Shuttles to complete oil and gas wells reduces the amount of time the drilling rig is used for standard completion purposes. The Smart Shuttles therefore allow the use of the drilling rig for its basic purpose - the drilling of oil and gas wells.

The present invention further includes a closed-loop system used to complete oil and gas wells. The term "to complete a well" means "to finish work on a well and bring it into productive status". A closed-loop system to complete an oil and gas well is an automated system under computer control that executes a sequence of programmed steps, but those steps depend in part upon information obtained from at least one downhole sensor that is communicated to the surface to optimize and/or change the steps executed by the computer to complete the well. The closed-loop system executes the steps during at least one significant portion of the well completion process. A type of Smart Shuttle comprised of a progressive cavity pump and an electrical submersible motor is particularly useful for such closed-loop systems. The completed well is comprised of at least a borehole in a geological formation surrounding a pipe located within the borehole. The pipe may be a metallic pipe; a casing string; a casing string with any retrievable drill bit removed from the wellbore; a steel pipe; a drill string; a drill string possessing a drill bit that remains attached to the end of the drill string after completing the wellbore; a drill string with any retrievable drill bit removed from the wellbore; a coiled tubing; a coiled tubing possessing a mud-motor drilling apparatus that remains attached to the coiled tubing after completing the wellbore; or a liner. Following the closed-loop well completion, apparatus monitoring the production of hydrocarbons from within the wellbore may be used to control the production of hydrocarbons from the wellbore. The closed-loop completion of oil and gas wells provides apparatus and methods of operation to substantially reduce the number of steps, the complexity, and the cost to complete oil and gas wells.

Accordingly, the closed-loop completion of oil and gas wells is a substantial improvement over present technology in the oil and gas industries.

The closed-loop control of a tractor deployer may also be used to complete an oil and gas well. Tractor deployer is used to complete a well, perform production and maintenance services on a well, and to perform enhanced recovery services on a well. The well servicing tractor deployer may be connected to surface instrumentation by a neutrally buoyant umbilical. Some of these umbilicals are made from composite materials.

Disclosure is provided of a method of drilling and completing a wellbore in a geological formation to produce hydrocarbons from a well comprising at least the following four steps: drilling the well with a retrievable drill bit attached to a casing; removing the retrievable drill bit from the casing; pumping down a one-way valve into the casing with a well fluid; and using the one-way valve to cement the casing into the wellbore.

Additional disclosure is provided that relates to drilling and completing wellbores in geological formations with different types of pipes having a variety of retrievable drill bits that are completed with pump-down cement one-way valves.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a section view of a rotary drill string having a rotary drill bit in the process of being cemented in place during one drilling pass into formation by using a

Latching Float Collar Valve Assembly that has been pumped into place above the rotary drill bit that is a preferred embodiment of the invention, where the rotary drill bit is a milled tooth rotary drill bit.

Figure 1A is substantially the same as Figure 1, except that stabilizer ribs have been welded to the Latching Float Collar Valve Assembly that also act as a centralizer, or centralizer means.

Figure 1B shows an external view of Figure 1A that shows three stabilizer ribs welded to the Latching Float Collar Valve Assembly, and the milled tooth rotary drill bit in Figure 1A has been replaced with a jet bit.

Figure 1C is substantially similar to Figure 1B, except here three stabilizer ribs have been welded to a bottomhole assembly ("BHA"), and the jet bit in Figure 1B has been replaced with a jet deflection roller cone bit.

Figure 1D shows three stabilizer ribs welded to a length of casing, and these ribs also act as a centralizer, or centralizer means.

Figure 1E shows a jet deflection bit attached to an angle-building bottomhole assembly having stabilizer ribs which are attached to a drill string.

Figure 1F shows the fluid passageways in a jet bit.

Figure 2 shows a section view of a rotary drill string having a rotary drill bit in the process of being cemented into place during one drilling pass into formation by using a Permanently Installed Float Collar Valve Assembly that is

permanently installed above the rotary drill bit that is a preferred embodiment of the invention.

Figure 3 shows a section view of a tubing conveyed mud motor drilling apparatus in the process of being cemented into place during one drilling pass into formation by using a Latching Float Collar Valve Assembly that has been pumped into place above the mud motor assembly that is a preferred embodiment of the invention.

Figure 4 shows a section view of a tubing conveyed mud motor drilling apparatus that in addition has several wiper plugs in the process of sequentially completing the well with gravel and then with cement during the one pass drilling and completion of the wellbore.

Figure 5 shows a section view of an apparatus for the one pass drilling and completion of extended reach lateral wellbores with a drill bit attached to a rotary drill string to produce hydrocarbons from offshore platforms.

Figure 6 shows a section view of an embodiment of the invention that is particularly configured so that Measurement-While-Drilling (MWD) and Logging-While-Drilling (LWD) can be done during rotary drilling operations with a Retrievable Instrumentation Package installed in place within a Smart Drilling and Completion Sub near the drill bit which is useful for the one pass drilling and completion of wellbores and which is also useful for standard well drilling procedures.

Figure 7 shows a section view of the Retrievable Instrumentation Package and the Smart Drilling and Completion Sub that also has directional drilling control apparatus and

instrumentation which is useful for the one pass drilling and completion of wellbores and which is also useful for standard well drilling operations.

Figure 8 shows a section view of the wellhead, the Wiper Plug Pump-Down Stack, the Smart Shuttle Chamber, the Wireline Lubricator System, the Smart Shuttle and the Retrieval Sub suspended by the wireline which is useful for the one pass drilling and completion of wellbores, and which is also useful for the completion of wells using cased well completion procedures.

Figure 9 shows a section view in detail of the Smart Shuttle and the Retrieval Sub while located in the Smart Shuttle Chamber.

Figure 10 shows a section view of the Smart Shuttle and the Retrieval Sub in a position where the elastomer sealing elements of the Smart Shuttle have sealed against the interior of the pipe, and the internal pump of the Smart Shuttle is ready to pump fluid volumes $\Delta V1$ from below the Smart Shuttle to above it so that the Smart Shuttle translates downhole.

Figure 11 is a generalized block diagram of one embodiment of a Smart Shuttle having a first electrically operated positive displacement pump and a second electrically operated pump.

Figure 12 shows a block diagram of a pump transmission device that prevents pump stalling, and other pump problems, by matching the load seen by the pump to the power available from the motor within the Smart Shuttle.

Figure 13 shows a block diagram of preferred embodiment of a Smart Shuttle having a hybrid pump design that also provides for a turbine assembly that causes a traction wheel to engage the casing to cause translation of the Smart Shuttle.

Figure 14 shows a block diagram of the computer control of the wireline drum and the Smart Shuttle in a preferred embodiment of the invention that allows the system to be operated as an Automated Smart Shuttle System, or "closed-loop completion system", that is useful for the closed-loop completion of one pass drilling operations, and that is also useful for completion operations within a standard casing string.

Figure 15 shows a section view of a rubber-type material wiper plug that can be attached to the Retrieval Sub and placed into the Wiper Plug Pump-Down Stack and subsequently used for the well completion process.

Figure 16 shows a section view of the Casing Saw that can be attached to the Retrieval Sub and conveyed downhole with the Smart Shuttle.

Figure 17 shows a section view of the wellhead, the Wiper Plug Pump-Down Stack, the Smart Shuttle Chamber, the Coiled Tubing Lubricator System, and the pump-down single zone packer apparatus suspended by the coiled tubing in the well before commencing the final single-zone completion of the well which in this case pertains to the one pass drilling and completion of wellbores, but that is also useful for standard cased well completions.

Figure 17A shows an expanded view of the pump-down single zone packer apparatus that is shown in Figure 17.

Figure 18 shows a "pipe means" deployed in the wellbore that may be a pipe made of any material, a metallic pipe, a steel pipe, a composite pipe, a drill pipe, a drill string, a casing, a casing string, a liner, a liner string, tubing, or a tubing string, or any means to convey oil and gas to the surface for production that may be completed using a Smart Shuttle, Retrieval Sub, and Smart Completion Devices. The "pipe means" is explicitly shown here so that it is crystal clear that various preferred embodiments cited above for use during the one pass drilling and completion of oil and gas wells can in addition also be used in standard well drilling and casing operations.

Figure 18A shows a modified and expanded form of Figure 18 wherein the last portion of the "pipe means" has "pipe mounted latching means" that may be used for a number of purposes including attaching a retrievable drill bit and/or as a positive "stop" for a pump-down one-way valve means following the retrieval of the retrievable drill bit during one pass drilling and completion operations.

Figure 18B shows a pump-down one-way valve means disposed within a pipe following the removal of a retrievable, or retractable, drill bit from the pipe. The pump-down one-way valve means is also called a cement float valve, or a one-way valve, for simplicity. One example of a pipe is a casing.

Figure 18C shows a retrievable, or retractable, drilling apparatus that possesses a retrievable, or retractable, drill

bit disposed in a pipe during drilling operations. One example of a pipe is a casing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, Figure 1 is the same as Figure 1 originally filed with U.S. Patent Application Serial No. 08/323,152, now U.S. Patent No. 5,551,521, except the artwork involving the shape of the arrows and other minor drafting details have been changed. In the following, the figures are substantially the same which have been filed with co-pending U.S. Patent Application Serial No. 10/189,570 except that Figures 1A, 1B, 1C, 1D, 1E, and 1F have been added.

In relation to Figure 1, and to Figures 2-5, apparatus and methods of operation of that apparatus are disclosed herein in the preferred embodiments of the invention that allow for cementation of a drill string with attached drill bit into place during one single drilling pass into a geological formation. The method of drilling the well and installing the casing becomes one single process that saves installation time and reduces costs during oil and gas well completion procedures as documented in the following description of the preferred embodiments of the invention. Apparatus and methods of operation of the apparatus are disclosed herein that use the typical mud passages already present in a typical rotary drill bit, including any watercourses in a "regular bit", or mud jets in a "jet bit", for the second independent purpose of passing cement into the annulus between the casing and the well while cementing the drill string in place. Slurry materials may be used for completion purposes in extended lateral wellbores.

The following text is substantially quoted from U.S. Patent Application Serial No. 08/323,152, now U.S. Patent No. 5,551,521, as it relates to Figure 1. The following text is also substantially quoted from U.S. Patent Application Serial No. 09/295,808, now U.S. Patent No. 6,263,987 B1, as it relates to Figures 2-5.

Figure 1 shows a section view of a drill string in the process of being cemented in place during one drilling pass into formation. A borehole 2 is drilled though the earth including geological formation 4. The borehole is drilled with a milled tooth rotary drill bit 6 having milled steel roller cones 8, 10, and 12 (not shown for simplicity). A standard water passage 14 is shown through the rotary cone drill bit. This rotary bit could equally be a tungsten carbide insert roller cone bit having jets for waterpassages, the principle of operation and the related apparatus being the same for either case for the preferred embodiment herein.

The threads 16 on rotary drill bit 6 are screwed into the Latching Subassembly 18. The Latching Subassembly is also called the Latching Sub for simplicity herein. The Latching Sub is a relatively thick-walled steel pipe having some functions similar to a standard drill collar.

The Latching Float Collar Valve Assembly 20 is pumped downhole with drilling mud after the depth of the well is reached. The Latching Float Collar Valve Assembly is pumped downhole with mud pressure pushing against the Upper Seal 22 of the Latching Float Collar Valve Assembly. The Latching Float Collar Valve Assembly latches into place into Latch Recession 24. The Latch 26 of the Latching Float Collar Valve Assembly is shown latched into place with Latching Spring 28 pushing against Latching Mandrel 30. When the

Latch 26 is properly seated into place within the Latch Recession 24, the clearances and materials of the Latch and mating Latch Recession are to be chosen such that very little cement will leak through the region of the Latch Recession 24 of the Latching Subassembly 18 under any back-pressure (upward pressure) in the well. Many means can be utilized to accomplish this task, including fabricating the Latch 26 from suitable rubber compounds, suitably designing the upper portion of the Latching Float Collar Valve Assembly 20 immediately below the Upper Seal 22, the use of various O-rings within or near Latch Recession 24, etc.

The Float 32 of the Latching Float Collar Valve Assembly seats against the Float Seating Surface 34 under the force from Float Collar Spring 36 that makes a one-way cement valve. However, the pressure applied to the mud or cement from the surface may force open the Float to allow mud or cement to be forced into the annulus generally designated as 38 in Figure 1. This one-way cement valve is a particular example of "a one-way cement valve means installed near the drill bit" which is a term defined herein. The one-way cement valve means may be installed at any distance from the drill bit but is preferentially installed "near" the drill bit.

Figure 1 corresponds to the situation where cement is in the process of being forced from the surface through the Latching Float Collar Valve Assembly. In fact, the top level of cement in the well is designated as element 40. Below 40, cement fills the annulus of the borehole. Above 40, mud fills the annulus of the borehole. For example, cement is present at position 42 and drilling mud is present at position 44 in Figure 1.

Relatively thin-wall casing, or drill pipe, designated as element 46 in Figure 1, is attached to the Latching Sub. The bottom male threads of the drill pipe 48 are screwed into the female threads 50 of the Latching Sub.

The drilling mud was wiped off the walls of the drill pipe in the well with Bottom Wiper Plug 52. The Bottom Wiper Plug is fabricated from rubber in the shape shown. Portions 54 and 56 of the Upper Seal of the Bottom Wiper Plug are shown in a ruptured condition in Figure 1. Initially, they sealed the upper portion of the Bottom Wiper Plug. Under pressure from cement, the Bottom Wiper Plug is pumped down into the well until the Lower Lobe of the Bottom Wiper Plug 58 latches into place into Latching Sub Recession 60 in the Latching Sub. After the Bottom Wiper Plug latches into place, the pressure of the cement ruptures The Upper Seal of the Bottom Wiper Plug. A Bottom Wiper Plug Lobe 62 is shown in Figure 1. Such lobes provide an efficient means to wipe the mud off the walls of the drill pipe while the Bottom Wiper Plug is pumped downhole with cement.

Top Wiper Plug 64 is being pumped downhole by water 66 under pressure in the drill pipe. As the Top Wiper Plug 64 is pumped down under water pressure, the cement remaining in region 68 is forced downward through the Bottom Wiper Plug, through the Latching Float Collar Valve Assembly, through the waterpassages of the drill bit and into the annulus in the well. A Top Wiper Plug Lobe 70 is shown in Figure 1. Such lobes provide an efficient means to wipe the cement off the walls of the drill pipe while the Top Wiper Plug is pumped downhole with water.

After the Bottom Surface 72 of the Top Wiper Plug is forced into the Top Surface 74 of the Bottom Wiper Plug,

almost the entire "cement charge" has been forced into the annulus between the drill pipe and the hole. As pressure is reduced on the water, the Float of the Latching Float Collar Valve Assembly seals against the Float Seating Surface 34. As the water pressure is reduced on the inside of the drill pipe, then the cement in the annulus between the drill pipe and the hole can cure under ambient hydrostatic conditions. This procedure herein provides an example of the proper operation of a "one-way cement valve means".

Therefore, the preferred embodiment in Figure 1 provides apparatus that uses the steel drill string attached to a drilling bit during drilling operations used to drill oil and gas wells for a second purpose as the casing that is cemented in place during typical oil and gas well completions.

The preferred embodiment in Figure 1 provides apparatus and methods of operation of the apparatus that results in the efficient installation of a cemented steel cased well during one single pass down into the earth of the steel drill string thereby making a steel cased borehole or cased well.

The steps described herein in relation to the preferred embodiment in Figure 1 provide a method of operation that uses the typical mud passages already present in a typical rotary drill bit, including any watercourses in a "regular bit", or mud jets in a "jet bit", that allow mud to circulate during typical drilling operations for the second independent, and the distinctly separate, purpose of passing cement into the annulus between the casing and the well while cementing the drill string into place during one single pass into the earth.

The preferred embodiment of the invention further provides apparatus and methods of operation that results in the pumping of cement down the drill string, through the mud passages in the drill bit, and into the annulus between the formation and the drill string for the purpose of cementing the drill string and the drill bit into place during one single drilling pass into the formation.

The apparatus described in the preferred embodiment in Figure 1 also provide a one-way cement valve and related devices installed near the drill bit of the drill string that allows the cement to set up efficiently while the drill string and drill bit are cemented into place during one single drilling pass into the formation.

Methods of operation of apparatus disclosed in Figure 1 have been disclosed that use the typical mud passages already present in a typical rotary drill bit, including any watercourses in a "regular bit", or mud jets in a "jet bit", for the second independent purpose of passing cement into the annulus between the casing and the well while cementing the drill string in place. This is a crucial step that allows a "Typical Drilling Process" involving some 14 steps to be compressed into the "New Drilling Process" that involves only 7 separate steps as described in detail below. The New Drilling Process is now possible because of "Several Recent Changes in the Industry" also described in detail below.

Typical procedures used in the oil and gas industries to drill and complete wells are well documented. For example, such procedures are documented in the entire "Rotary Drilling Series" published by the Petroleum Extension Service of The University of Texas at Austin, Austin, Texas that is

incorporated herein by reference in its entirety comprised of the following: Unit I - "The Rig and Its Maintenance" (12 Lessons); Unit II - "Normal Drilling Operations" (5 Lessons); Unit III - Nonroutine Rig Operations (4 Lessons); Unit IV - Man Management and Rig Management (1 Lesson); and Unit V - Offshore Technology (9 Lessons). All of the individual Glossaries of all of the above Lessons in their entirety are also explicitly incorporated herein, and all definitions in those Glossaries shall be considered to be explicitly referenced and/or defined herein.

Additional procedures used in the oil and gas industries to drill and complete wells are well documented in the series entitled "Lessons in Well Servicing and Workover" published by the Petroleum Extension Service of The University of Texas at Austin, Austin, Texas that is incorporated herein by reference in its entirety comprised of all 12 Lessons. All of the individual Glossaries of all of the above Lessons in their entirety are also explicitly incorporated herein, and any and all definitions in those Glossaries shall be considered to be explicitly referenced and/or defined herein.

With reference to typical practices in the oil and gas industries, a typical drilling process may therefore be described in the following.

Typical Drilling Process

From an historical perspective, completing oil and gas wells using rotary drilling techniques have in recent times comprised the following typical steps:

Step 1. With a pile driver or rotary rig, install any necessary conductor pipe on the surface for attachment of the blowout preventer and for mechanical support at the wellhead.

Step 2. Install and cement into place any surface casing necessary to prevent washouts and cave-ins near the surface, and to prevent the contamination of freshwater sands as directed by state and federal regulations.

Step 3. Choose the dimensions of the drill bit to result in the desired sized production well. Begin rotary drilling of the production well with a first drill bit. Simultaneously circulate drilling mud into the well while drilling. Drilling mud is circulated downhole to carry rock chips to the surface, to prevent blowouts, to prevent excessive mud loss into formation, to cool the bit, and to clean the bit. After the first bit wears out, pull the drill string out, change bits, lower the drill string into the well and continue drilling. It should be noted here that each "trip" of the drill bit typically requires many hours of rig time to accomplish the disassembly and reassembly of the drill string, pipe segment by pipe segment. Here, each pipe segment may consist of several pipe joints.

Step 4. Drill the production well using a succession of rotary drill bits attached to the drill string until the hole is drilled to its final depth.

Step 5. After the final depth is reached, pull out the drill string and its attached drill bit.

Step 6. Perform open-hole logging of the geological formations to determine the quantitative amounts of oil and

gas present. This typically involves making physical measurements that are used to determine the porosity of the rock, the electrical resistivity of the water present, the electrical resistivity of the rock, the total amounts of oil and gas present, the relative amounts of oil and gas present, and the use of Archie's Equations (or their equivalent representation, or their approximation by other algebraic expressions, or their substitution for similar geophysical analysis). Here, such open-hole physical measurements include electrical measurements, inductive measurements, acoustic measurements, natural gamma ray measurements, neutron measurements, and other types of nuclear measurements, etc. Such measurements may also be used to determine the permeability of the rock. If no oil and gas is present from the analysis of such open-hole logs, an option can be chosen to cement the well shut. If commercial amounts of oil and gas are present, continue the following steps.

Step 7. Typically reassemble the drill bit and the drill string in the well to clean the well after open-hole logging.

Step 8. Pull out the drill string and its attached drill bit.

Step 9. Attach the casing shoe into the bottom male pipe threads of the first length of casing to be installed into the well. This casing shoe may or may not have a one-way valve ("casing shoe valve") installed in its interior to prevent fluids from back-flowing from the well into the casing string.

Step 10. Typically install the float collar onto the top female threads of the first length of casing to be

installed into the well which has a one-way valve ("float collar valve") that allows the mud and cement to pass only one way down into the hole thereby preventing any fluids from back-flowing from the well into the casing string. Therefore, a typical installation has a casing shoe attached to the bottom and the float collar valve attached to the top portion of the first length of casing to be lowered into the well. The float collar and the casing shoe are often installed into one assembly for convenience that entirely replace this first length of casing. Please refer to the book entitled "Casing and Cementing", Unit II, Lesson 4, Second Edition, of the Rotary Drilling Series, Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1982 (hereinafter defined as "Ref.1"), an entire copy of which is incorporated herein by reference. In particular, please refer to pages 28-35 of that book (Ref. 1). All of the individual definitions of words and phrases in the Glossary of Ref. 1 are also explicitly and separately incorporated herein in their entirety by reference.

Step 11. Assemble and lower the production casing into the well while back filling each section of casing with mud as it enters the well to overcome the buoyancy effects of the air filled casing (caused by the presence of the float collar valve), to help avoid sticking problems with the casing, and to prevent the possible collapse of the casing due to accumulated build-up of hydrostatic pressure.

Step 12. To "cure the cement under ambient hydrostatic conditions", typically execute a two-plug cementing procedure involving a first Bottom Wiper Plug before and a second Top Wiper Plug behind the cement that also minimizes cement contamination problems comprised of the following individual steps:

A. Introduce the Bottom Wiper Plug into the interior of the steel casing assembled in the well and pump down with cement that cleans the mud off the walls and separates the mud and cement (Ref. 1, pages 28-35).

B. Introduce the Top Wiper Plug into the interior of the steel casing assembled into the well and pump down with water under pump pressure thereby forcing the cement through the float collar valve and any other one-way valves present (Ref. 1, pages 28-35).

C. After the Bottom Wiper Plug and the Top Wiper Plug have seated in the float collar, release the pump pressure on the water column in the casing that results in the closing of the float collar valve which in turn prevents cement from backing up into the interior of the casing. The resulting interior pressure release on the inside of the casing upon closure of the float collar valve prevents distortions of the casing that might prevent a good cement seal (Ref. 1, page 30). In such circumstances, "the cement is cured under ambient hydrostatic conditions".

Step 13. Allow the cement to cure.

Step 14. Follow normal "final completion operations" that include installing the tubing with packers and perforating the casing near the producing zones. For a description of such normal final completion operations, please refer to the book entitled "Well Completion Methods", Well Servicing and Workover, Lesson 4, from the series entitled "Lessons in Well Servicing and Workover", Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1971 (hereinafter defined as "Ref. 2"), an entire copy of which is incorporated herein by reference. All of

the individual definitions of words and phrases in the Glossary of Ref. 2 are also explicitly and separately incorporated herein in their entirety by reference. Other methods of completing the well are described therein that shall, for the purposes of this application herein, also be called "final completion operations".

Several Recent Changes in the Industry

Several recent concurrent changes in the industry have made it possible to reduce the number of steps defined above. These changes include the following:

a. Until recently, drill bits typically wore out during drilling operations before the desired depth was reached by the production well. However, certain drill bits have recently been able to drill a hole without having to be changed. For example, please refer to the book entitled "The Bit", Unit I, Lesson 2, Third Edition, of the Rotary Drilling Series, The University of Texas at Austin, Austin, Texas, 1981 (hereinafter defined as "Ref. 3"), an entire copy of which is incorporated herein by reference. All of the individual definitions of words and phrases in the Glossary of Ref. 3 are also explicitly and separately incorporated herein in their entirety by reference. On page 1 of Ref. 3 it states: "For example, often only one bit is needed to make a hole in which the casing will be set." On page 12 of Ref. 3 it states in relation to tungsten carbide insert roller cone bits: "Bit runs as long as 300 hours have been achieved; in some instances, only one or two bits have been needed to drill a well to total depth." This is particularly so since the advent of the sealed bearing tri-cone bit designs appeared in 1959 (Ref. 3, page 7) having tungsten

carbide inserts (Ref. 3, page 12). Therefore, it is now practical to talk about drill bits lasting long enough for drilling a well during one pass into the formation, or "one pass drilling".

b. Until recently, it has been impossible or impractical to obtain sufficient geophysical information to determine the presence or absence of oil and gas from inside steel pipes in wells. Heretofore, either standard open-hole logging tools or Measurement-While-Drilling ("MWD") tools were used in the open hole to obtain such information. Therefore, the industry has historically used various open-hole tools to measure formation characteristics. However, it has recently become possible to measure the various geophysical quantities listed in Step 6 above from inside steel pipes such as drill strings and casing strings. For example, please refer to the book entitled "Cased Hole Log Interpretation Principles/Applications", Schlumberger Educational Services, Houston, Texas, 1989, an entire copy of which is incorporated herein by reference. Please also refer to the article entitled "Electrical Logging: State-of-the-Art", by Robert E. Maute, The Log Analyst, May-June 1992, pages 206-227, an entire copy of which is incorporated herein by reference.

Because drill bits typically wore out during drilling operations until recently, different types of metal pipes have historically evolved which are attached to drilling bits, which, when assembled, are called "drill strings". Those drill strings are different than typical "casing strings" run into the well. Because it was historically absolutely necessary to do open-hole logging to determine the presence or absence of oil and gas, the fact that different types of pipes were used in "drill strings" and "casing

strings" was of little consequence to the economics of completing wells. However, it is possible to choose the "drill string" to be acceptable for a second use, namely as the "casing string" that is to be installed after drilling has been completed.

New Drilling Process

Therefore, the preferred embodiments of the invention herein reduces and simplifies the above 14 steps as follows:

Repeat Steps 1 - 2 above.

Steps 3 - 5 (Revised). Choose the drill bit so that the entire production well can be drilled to its final depth using only one single drill bit. Choose the dimensions of the drill bit for desired size of the production well. If the cement is to be cured under ambient hydrostatic conditions, attach the drill bit to the bottom female threads of the Latching Subassembly ("Latching Sub"). Choose the material of the drill string from pipe material that can also be used as the casing string. Here, any pipe made of any material may be used including metallic pipe, composite pipe, fiberglass pipe, and hybrid pipe made of a mixture of different materials, etc. As an example, a composite pipe may be manufactured from carbon fiber-epoxy resin materials. Attach the first section of drill pipe to the top female threads of the Latching Sub. Then rotary drill the production well to its final depth during "one pass drilling" into the well. While drilling, simultaneously circulate drilling mud to carry the rock chips to the surface, to prevent blowouts, to prevent excessive mud loss into formation, to cool the bit, and to clean the bit.

Step 6 (Revised). After the final depth of the production well is reached, perform logging of the geological formations to determine the amount of oil and gas present from inside the drill pipe of the drill string. This typically involves measurements from inside the drill string of the necessary geophysical quantities as summarized in Item "b." of "Several Recent Changes in the Industry". If such logs obtained from inside the drill string show that no oil or gas is present, then the drill string can be pulled out of the well and the well filled in with cement. If commercial amounts of oil and gas are present, continue the following steps.

Steps 7 - 11 (Revised). If the cement is to be cured under ambient hydrostatic conditions, pump down a Latching Float Collar Valve Assembly with mud until it latches into place in the notches provided in the Latching Sub located above the drill bit.

Steps 12 - 13 (Revised). To "cure the cement under ambient hydrostatic conditions", typically execute a two-plug cementing procedure involving a first Bottom Wiper Plug before and a second Top Wiper Plug behind the cement that also minimizes cement contamination comprised of the following individual steps:

A. Introduce the Bottom Wiper Plug into the interior of the drill string assembled in the well and pump down with cement that cleans the mud off the walls and separates the mud and cement.

B. Introduce the Top Wiper Plug into the interior of the drill string assembled into the well and pump down with water thereby forcing the cement through any Float

Collar Valve Assembly present and through the watercourses in "a regular bit" or through the mud nozzles of a "jet bit" or through any other mud passages in the drill bit into the annulus between the drill string and the formation.

C. After the Bottom Wiper Plug, and Top Wiper Plug have seated in the Latching Float Collar Valve Assembly, release the pressure on the interior of the drill string that results in the closing of the float collar which in turn prevents cement from backing up in the drill string. The resulting pressure release upon closure of the float collar prevents distortions of the drill string that might prevent a good cement seal as described earlier. I.e., "the cement is cured under ambient hydrostatic conditions".

Repeat Step 14 above.

Therefore, the "New Drilling Process" has only 7 distinct steps instead of the 14 steps in the "Typical Drilling Process". The "New Drilling Process" consequently has fewer steps, is easier to implement, and will be less expensive. The "New Drilling Process" takes less time to drill a well. This faster process has considerable commercial significance.

The preferred embodiment of the invention disclosed in Figure 1 requires a Latching Subassembly and a Latching Float Collar Valve Assembly. An advantage of this approach is that the Float 32 of the Latching Float Collar Valve Assembly and the Float Seating Surface 34 in Figure 1 are installed at the end of the drilling process and are not subject to any wear by mud passing down during normal drilling operations.

The drill bit described in Figure 1 is a milled steel toothed roller cone bit. However, any rotary bit can be used with the invention. A tungsten carbide insert roller cone bit can be used. Any type of diamond bit or drag bit can be used. The invention may be used with any drill bit described in Ref. 3 above that possesses mud passages, waterpassages, or passages for gas. Any type of rotary drill bit can be used possessing such passageways. Similarly, any type of bit whatsoever that utilizes any fluid or gas that passes through passageways in the bit can be used whether or not the bit rotates.

In accordance with the above description, a preferred embodiment of the invention is a method of making a cased wellbore comprising at least the steps of: (a) assembling a lower segment of a drill string comprising in sequence from top to bottom a first hollow segment of drill pipe, a latching subassembly means and a rotary drill bit having at least one mud passage for passing drilling mud from the interior of the drill string to the outside of the drill string; (b) rotary drilling the well into the earth to a predetermined depth with the drill string by attaching successive lengths of hollow drill pipes to the lower segment of the drill string and by circulating mud from the interior of the drill string to the outside of the drill string during rotary drilling so as to produce a wellbore; (c) after the predetermined depth is reached, pumping a latching float collar valve means down the interior of the drill string with drilling mud until it seats into place within the latching subassembly means; (d) pumping a bottom wiper plug means down the interior of the drill string with cement until the bottom wiper plug means seats on the upper portion of the latching float collar valve means so as to clean the mud from the interior of the drill string; (e) pumping any required

additional amount of cement into the wellbore by forcing it through a portion of the bottom wiper plug means and through at least one mud passage of the drill bit into the wellbore; (f) pumping a top wiper plug means down the interior of the drill string with water until the top wiper plug seats on the upper portion of the bottom wiper plug means thereby cleaning the interior of the drill string and forcing additional cement into the wellbore through at least one mud passage of the drill bit; and (g) allowing the cement to cure, thereby cementing into place the drill string to make a cased wellbore.

In accordance with the above description, another preferred embodiment of the invention is the rotary drilling apparatus to drill a borehole into the earth comprising a hollow drill string attached to a rotary drill bit having at least one mud passage for passing the drilling mud from within the hollow drill string to the borehole, a source of drilling mud, a source of cement, and at least one latching float collar valve means that is pumped with the drilling mud into place above the rotary drill bit to install the latching float collar means within the hollow drill string above the rotary drill bit that is used to cement the drill string and rotary drill bit into the earth during one pass into the formation of the drill string to make a steel cased well.

In accordance with the above description, yet another preferred embodiment of the invention is a method of drilling a well from the surface of the earth and cementing a drill string into place within a wellbore to make a cased well during one pass into formation using an apparatus comprising at least a hollow drill string attached to a rotary drill bit, the bit having at least one mud passage to convey drilling mud from the interior of the drill string to the

wellbore, a source of drilling mud, a source of cement, and at least one latching float collar valve assembly means, using at least the following steps: (a) pumping the latching float collar valve means from the surface of the earth through the hollow drill string with drilling mud so as to seat the latching float collar valve means above the drill bit; and (b) pumping cement through the seated latching float collar valve means to cement the drill string and rotary drill bit into place within the wellbore.

Figure 1A shows another preferred embodiment of the invention. Figure 1A shows a sectional view of the embodiment shown in Figure 1 with the following exceptions. In Figure 1A, the first stabilizer rib 75, and the second stabilizer rib 77 are shown welded to the exterior of the Latching Subassembly 18 of Figure 1. The third stabilizer rib 79 (which is shown in Figures 1B and 1C that are described below) is not shown in this section view. Also shown is a diameter of the wellbore at a specific depth designated by the distance between arrows A and B shown in Figure 1A. The specific depth is defined by the variable Z which is not shown in Figure 1A for the purposes of simplicity. Sets of one or more stabilizer ribs comprise one preferred type of stabilizer. Unit III, Lesson 1, of the Rotary Drilling Series, previously incorporated by reference above in Serial No. 08/323,152, now U.S. Patent No. 5,551,521 (which is the original parent application of this invention, hereinafter "the '521 patent"), on page 36, states the following with regards to stabilizers: "... blade-type stabilizer ribs may be welded onto the lower end of the housing...". Figure 48 in that Unit III, Lesson 1, on page 35, shows such stabilizers welded onto a "bottomhole assembly". Such a bottomhole assembly is also called a drilling apparatus. Unit II, Lesson 3, of the Rotary

Drilling Series, previously incorporated by reference in the '521 patent, shows various types of stabilizer arrangements in Figure 18 on page 15, and in Figure 22 on page 21 that is described on pages 20-22. These are all examples of drilling stabilizer means. In particular, the type of stabilizer shown in Figure 1A derives from the sketch shown as "A" in Figure 22 within that Unit II, Lesson 3. There are many other references to a stabilizer, or stabilizers, in the Rotary Drilling Series and in the series entitled "Lessons in Well Servicing and Workover", previously incorporated in their entirety by reference in the '521 patent. Each such stabilizer, or stabilizers, is an example of a drilling stabilizer means.

Stabilizers are used to stabilize the bottomhole assembly (BHA) as described in Unit III, Lesson 1, of the Rotary Drilling Series, previously incorporated by reference in the '521 patent, in the section entitled "Bottomhole Assemblies" on pages 33-35. Accordingly, stabilizers are used as a method for stabilizing the drill string while drilling the wellbore.

Stabilizers are also used to centralize the drilling apparatus in the wellbore. The utility of centralizers during cementing operations is summarized in Unit II, Lesson 4, of the Rotary Drilling Series, previously incorporated by reference in the '521 patent, as particularly explained on page 1, in Figure 26 on page 29, in Figure 33 on page 35 entitled "centralizers" and in the related text on pages 35-38. The utility of centralizers during cementing operations is further summarized in Lesson 4 of the series entitled "Lessons in Well Servicing and Workover", previously incorporated by reference in the '521 patent, on page 15, in Figure 17 on page 18 and in the related text on pages 18-23,

and on page 27. Accordingly, such stabilizers that also act as centralizers are used as a method for maintaining the casing portion in a substantially centralized position in relation to a diameter of the wellbore. Element 46 in Figure 1A is relatively thin-wall casing, or drill pipe as the case may be. As already described above, various different drilling stabilizer means may be used as centralizer means so that at least a portion of the drill string is centralized in the well while cementing the drill string into place within the wellbore by the presence of the drilling stabilizer means. Accordingly, for the purposes herein, the stabilizer ribs 75, 77, and 79 may also be called centralizer ribs 75, 77, and 79. Such a set of centralizer ribs is one preferred embodiment of a centralizer means. So, an equivalent name for stabilizer rib 75 is centralizer rib 75. An equivalent name for stabilizer rib 77 is centralizer rib 77. An equivalent name for stabilizer rib 79 is centralizer rib 79. The relative scale for the stabilizer ribs 75 and 77 in Figure 1 has been chosen to avoid confusion and for the purpose of simplicity.

Figure 1B is an external view of the assembly shown in Figure 1A, except here the milled tooth rotary drill bit 6 in Figure 1A is replaced with a jet bit 7 that has been previously described above, that has jet nozzle 9. Stabilizer rib 79 is shown in Figure 1B along with stabilizer ribs 75 and 77 that were previously described. The scale of these stabilizer ribs in Figure 1B does not correspond to the scale in Figure 1A (that was chosen to prevent confusion and for the purpose of simplicity in Figure 1A). These stabilizer ribs are attached to the Latching Subassembly 18 in Figure 1B. The Latching Subassembly 18 is attached to element 46 by a typical threaded pipe joint 19. Element 46 in Figure 1 is quoted from above as a "relatively thin-walled

casing, or drill pipe" as the case may be. The three stabilizer ribs shown in Figure 1B are an example of multiple stabilizer ribs attached to the exterior of a latching subassembly means to stabilize the drill string during drilling. Unit I, Lesson 2, of the Rotary Drilling Series, previously incorporated by reference in the '521 patent, shows diagrams of jet nozzles in Figure 5 on page 4, in Figure 22 on page 18, and there is a section entitled "Jet nozzle factors" on page 13 that describes jet nozzles. It should be appreciated that the multiple stabilizer ribs may be attached to any portion of the drilling apparatus. Accordingly, the multiple stabilizer ribs may be attached to some, or all, of the individual lengths of casings that make up the drill string. As stated before, stabilizer ribs 75, 77, and 79 may also act as centralizer ribs, constituting one preferred embodiment of a centralizer means.

Figure 1C is the same as Figure 1B except the jet bit 7 has been replaced with jet deflection roller cone bit 11 having an eccentric jet nozzle 13 that is used for directional drilling. In addition, the Latching Subassembly 18 in Figure 1B is replaced with any suitable bottomhole assembly (BHA) 21. The upper portion of the bottomhole assembly 21 is attached to element 46 by a suitable threaded joint 23. The external elements of Figure 1C are very similar to those shown in the Unit III, Lesson 1, of the Rotary Drilling Series, previously incorporated by reference in the '521 patent, in Figure 32 on page 25 and also shown in Figure 1E of the current application. Figure 31 on page 25 of that Unit III, Lesson 1, shows a "jet deflection roller cone bit", which is used for directional drilling purposes as explained in the section entitled "Jet deflection bits" on pages 25-26 of that Unit III, Lesson 1. Unit I, Lesson 2, of the Rotary Drilling Series, previously incorporated by

reference in the '521 patent, shows diagrams of a jet bit having an eccentric orifice used for directional drilling in Figure 22 on page 18, and in Figure 51 on page 39. For example, in relation to that Figure 22 on page 18 of that Unit I, Lesson 2, it states: "...and the large jet is pointed so that, when pump pressure is applied, the jet washes out the side of the hole in a specific direction." As another example, in relation to that Figure 51 on page 39 of that Unit I, Lesson 1, it further states: "Special-purpose jet bits have also been designed for use in directional drilling." This page 39 of that Unit I, Lesson 1, further states: "The large amount of mud emitted from the enlarged jet washes away the formation in front of the bit, and the bit follows the path of least resistance." Accordingly, this type of bit provides a means to perform directional drilling. Accordingly, this apparatus provides a directional drilling means. Put another way, this is a rotary drilling apparatus to drill a borehole into the earth comprising a hollow drill string possessing directional drilling means comprised of a jet deflection bit having at least one mud passage for passing drilling mud from within the hollow drill string to the borehole. Figure 1C also shows centralizer ribs 75, 77, and 79 that were previously described. These three stabilizer ribs shown in Figure 1C are another example of multiple stabilizer ribs attached to the exterior of a latching subassembly means to stabilize the drill string during drilling. It should be appreciated that the multiple stabilizer ribs may be attached to any portion of the drilling apparatus. Accordingly, the multiple stabilizer ribs may be attached to some, or all, of the individual lengths of casings that make up the drill string. As stated before, stabilizer ribs 75, 77, and 79 are also used as centralizer ribs 75, 77, and 79 constituting one preferred embodiment of a centralizer means.

Figure 1D shows stabilizer ribs 81, 83, and 85 attached to a typical length of casing 87. Casing 87 is attached to upper casing 89 by threaded joint 91. Casing 87 is attached to lower casing 93 by threaded joint 95. Accordingly, the multiple stabilizer ribs may be attached to some, or all, of the individual lengths of casings that make up the drill string. The stabilizer ribs act to stabilize the drill string made of at least a portion of casing lengths as shown in Figure 1D. A drill string having one or more casing lengths with stabilizer ribs attached is yet another embodiment of drilling stabilizer means. As previously explained above in relation to Figure 1A, such stabilizers that also act as centralizers are used as a method for maintaining the casing portion in a substantially centralized position in relation to a diameter of the wellbore.
As already described above, various different drilling stabilizer means may be used as centralizer means so that at least a portion of the drill string is centralized in the well while cementing the drill string into place within the wellbore by the presence of the drilling stabilizer means.
In one embodiment, an upper drill string made from drill pipe is attached to a lower set of casings assembled in the well.
Stabilizer ribs 81, 83, and 85 may also be called equivalently centralizer ribs 81, 83 and 85 for the purposes herein and are one preferred embodiment of a centralization means.

In the above, stabilizer ribs attached to drill strings have been described which are examples of stabilization means. In the above, stabilizer ribs have been described that act as centralization means. Accordingly, one preferred embodiment of the invention is the method of using stabilization means attached to drill strings to act as

centralization means when the drill strings are cemented into place in a wellbore as the well casing.

The various drill bits drill through different earth formations. Lesson 2 of the series entitled "Lessons in Well Servicing and Workover", that was previously incorporated by reference in the '521 patent, on pages 2-10, describes rocks and minerals, sedimentary rocks, shale, metamorphic rocks, igneous rocks, as examples of earth formations. Unit I, Lesson 2, of the Rotary Drilling Series, previously incorporated by reference in the '521 patent, on page 1, describes "rock formations" and states: "formations consist of alternating layers of soft material, hard rocks, and abrasive sections". During the drilling process, the drill bit removes the different portions of earth formations, and then the mud transports the cuttings from the earth formations to the surface. Different drill bits have been described including the milled tooth rotary drill bit 6 having milled steel roller cones in Figure 1; the jet bit 7 in Figure 1B; and the jet deflection roller cone bit 11 in Figure 1C. There are yet other types of drill bits described in Unit I, Lesson 2, of the Rotary Drilling Series, previously incorporated by reference in the '521 patent. Any type of rotary drill bit whatsoever may be used to drill the borehole through the earth. These different types of drill bits all remove portions of earth formations. Accordingly, each different drill bit attached to a drill string is an earth removal member, a term that is defined herein. The earth removal member may also be defined to be an earth removal means and/or a drill bit means. The terms "earth removal member", "earth removal member means", "earth removal means", and "drill bit means" may be used interchangeably for the purposes of this invention.

Element 46 in Figure 1 is quoted from above as "relatively thin-walled casing, or drill pipe" as the case may be. Element 46 is also so identified in Figure 1A, in Figure 1B, and in Figure 1C. In Figure 1, the Latching Subassembly 18 is used to operatively connect the earth removal member (6) to a drill pipe (46). In Figure 1, elements 6, 18, and 46, and the related description provide a method of drilling the wellbore using a drill string, the drill string having an earth removal member operatively connected thereto. The term "drill string" in relation to Figure 1 includes elements 6, 18, and 46. In a preferred embodiment, element 46 is that portion of the drill string that is casing which is used to line the wellbore. In accordance with the invention, element 46 is also used as a casing portion for lining the wellbore. Previous description in relation to Figure 1 describes methods of locating the casing portion 46 within the wellbore.

In accordance with the above, a preferred embodiment of the invention is a rotary drilling apparatus to drill a borehole into the earth comprising a hollow drill string possessing at least one drilling stabilizer means, the drill string attached to a rotary drill bit having at least one mud passage for passing the drilling mud from within the hollow drill string to the borehole, a source of drilling mud, a source of cement, and at least one latching float collar valve means that is pumped with the drilling mud into place above the rotary drill bit to install the latching float collar means within the hollow drill string above the rotary drill bit that is used to cement the drill string and rotary drill bit into the earth during one pass into the formation of the drill string to make a steel cased well.

In accordance with the above, another preferred embodiment of the invention is a method of drilling a well from the surface of the earth and cementing a drill string into place within a wellbore to make a cased well during one pass into formation using an apparatus comprising at least a hollow drill string possessing at least one drilling stabilizer means, the drill string attached to a rotary drill bit, the bit having at least one mud passage to convey drilling mud from the interior of the drill string to the wellbore, a source of drilling mud, a source of cement, and at least one latching float collar valve assembly means, using at least the following steps: (a) pumping the latching float collar valve means from the surface of the earth through the hollow drill string with drilling mud so as to seat the latching float collar valve means above the drill bit; and (b) pumping cement through the seated latching float collar valve means to cement the drill string and rotary drill bit into place within the wellbore, whereby at least a portion of the drill string is centralized in the well while cementing the drill string into place within the wellbore by the presence of the drilling stabilizer means.

In accordance with the above, a preferred embodiment of the invention provides a method for drilling and lining a wellbore comprising: drilling the wellbore using a drill string, the drill string having an earth removal member operatively connected thereto and a casing portion for lining the wellbore; stabilizing the drill string while drilling the wellbore; locating the casing portion within the wellbore; and maintaining the casing portion in a substantially centralized position in relation to a diameter of the wellbore.

In accordance with the above, another preferred embodiment of the invention is the method wherein following the lining of the wellbore with the above defined casing portion, the casing portion is cemented into place using at least the following steps: (a) pumping a latching float collar valve means from the surface of the earth through the drill string with drilling mud so as to seat the latching float collar valve means above the earth removal member, wherein the earth removal member possesses at least one mud passage to convey drilling mud from the interior of the drill string to the wellbore; and (b) pumping cement through the seated latching float collar valve means to cement the drill string and the earth removal member into place within the wellbore.

Figure 1E is a rendition of the left-hand portion of Figure 32 on page 25 of Unit III, Lesson 1, of the Rotary Drilling Series. An entire copy of Unit III, Lesson 1, of the Rotary Drilling Series was previously incorporated by reference into the '521 patent. The title of that Figure 32 is "Deflecting Hole with Jet Deflection Bit". Jet deflection bit 15 is attached to "an angle-building bottomhole assembly" 17 having stabilizer rib 97. The phrase "an angle-building bottomhole assembly" is defined on page 25 of Unit III, Lesson 1, of the Rotary Drilling Series. That angle-building bottomhole assembly 17 is in turn attached to drill pipe. Drilling with stabilizers attached to drill pipe is shown in Figure 1E.

Figure 1F is a rendition of Figure 5 on page 4 of Unit I, Lesson 2, of the Rotary Drilling Series. An entire copy of Unit I, Lesson 2, of the Rotary Drilling Series was previously incorporated by reference in the '521 patent. The title of that Figure 5 is "Fluid Passageways in a Jet

Bit". Jet bit 31 is shown in Figure 1F. Three mud jets are shown in Figure 1F, although they are not numbered.

The directional drilling of wells was described above in relation to Figure 1C. Unit III, Lesson 1, of the Rotary Drilling Series, previously incorporated by reference in the '521 patent, describes "directional wells" on page 2; "directional drilling" on page 2; and "steering tools" on page 19. As stated above in relation to Figure 1C, that Unit III, Lesson 1, describes how to use a jet deflection bit, and for example, on page 25 thereof, it states the following: "The tool face (the side of the bit with the oversize nozzle) is oriented in the desired direction, the pumps started, and the drill string worked slowly up and down, without rotation, about 10 feet off the bottom. This action washes out the formation on one side (fig. 32). When rotation is started and weight applied, the bit tends to follow the path of least resistance - the washed-out section."

That Unit III, Lesson 1, on page 44 of the Glossary, also defines the term "measurement while drilling" to be the following: "1. directional surveying during routine drilling operations to determine the angle and direction by which the wellbore deviates from the vertical. 2. any system of measuring downhole conditions during routine drilling operations." That Unit III, Lesson 1, page 18, further describes a "steering tool" to be a "wireline telemetry surveying instrument that measures inclination and direction while drilling is in progress (fig. 22)." A wireline steering tool is shown in Figure 22 on page 19 of that Unit III, Lesson 1. The steering tool is periodically introduced into the wellbore while the rotary drilling is temporarily stopped, the direction of the well is suitably

measured, the tool face properly oriented as described in the previous paragraph, the well suitably directionally drilled as described in the previous paragraph, and then the steering tool is removed from the well and rotary drilling commenced. The steering tool is removed from the drill pipe before completion operations begin. The steering tool is an example of a steering tool means, that is also called a directional surveying means, which measures the direction of the wellbore being drilled. Accordingly, methods and apparatus have been described that provide for periodically halting rotary drilling, introducing into the wellbore a directional surveying means to determine the direction of the wellbore being drilled, and thereafter removing the directional surveying means from the wellbore.

A steering tool may be used with jet deflection bits and with downhole mud motors (the mud motors will be described in detail later). Accordingly, the orientation of the jet deflection bit determines the directional drilling of the borehole, and the steering tool may be used to measure its direction. The orientation of the jet deflection bit may be changed at will depending upon the directional information received from the steering tool. Therefore, methods and apparatus have been described which may be used to determine and change a drilling trajectory of a well. Accordingly, methods and apparatus have been provided for rotary drilling the well into the earth in a desired direction. Accordingly, methods and apparatus have been described for selectively causing a drilling trajectory to change during the drilling of a well. Accordingly, apparatus has been provided that is a directional drilling means. As described above, one type of directional drilling means includes a jet deflection bit. There are many other types of directional drilling means as described in Unit III, Lesson 1, of the Rotary Drilling

Series. Put another way, one preferred embodiment the invention is a rotary drilling apparatus to drill a borehole into the earth comprising a hollow drill string possessing directional drilling means comprising a jet deflection bit having at least one mud passage for passing the drilling mud from within the hollow drill string to the borehole.

Accordingly, a preferred embodiment of the invention is a method of directional drilling a well from the surface of the earth and cementing a drill string into place within a wellbore to make a cased well during one pass into formation using an apparatus comprising at least a hollow drill string attached to a rotary drill bit possessing directional drilling means, the bit having at least one mud passage to convey drilling mud from the interior of the drill string to the wellbore, a source of drilling mud, a source of cement, and at least one latching float collar valve assembly means.

In relation to Figures 1, 1A, 1B, and 1C, element 46 has been previously described as a casing portion for lining the wellbore. Accordingly, methods and apparatus have been described for lining the wellbore with the casing portion. The term "earth removal member" has been previously defined above. Therefore, a preferred embodiment of the invention is a method for drilling and lining a wellbore comprising: drilling the wellbore using a drill string, the drill string having an earth removal member operatively connected thereto and a casing portion for lining the wellbore; selectively causing a drilling trajectory to change during the drilling; and lining the wellbore with the casing portion.

In an embodiment of the present invention, the phrase "selectively causing a drilling trajectory to change during

drilling" may include the following. The term "during drilling" may mean, in one embodiment of the present invention, that any measurements required are performed without having to remove the casing from the well, so that any "directional drilling measurement means" used in this drilling process would not require the removal of the casing from the well. "Selectively" may mean, in one embodiment, that the direction may be determined at any time during the drilling, and the direction of the drilling changed at any time during drilling, at will, without removing the casing from the well, or without drilling any advanced holes into the earth. The term "selectively" may also be defined to mean, in one embodiment of the present invention, that the direction of drilling may be measured any number of times with a directional drilling measurement means, and the direction of the drilling may be changed any number of times with a directional drilling means, without removing the casing from the well, or without drilling any advanced holes into the earth.

Another preferred embodiment of the invention is the above method, wherein following the lining of the wellbore with the casing portion, the casing portion is cemented into place using at least the following steps: (a) pumping a latching float collar valve means from the surface of the earth through the drill string with drilling mud so as to seat the latching float collar valve means above the earth removal member, whereby the earth removal member possesses at least one mud passage to convey drilling mud from the interior of the drill string to the wellbore; and (b) pumping cement through the seated latching float collar valve means to cement the drill string and earth removal member into place within the wellbore.

Step 6 (Revised), as quoted above, and from the '521 patent, states the following: "After the final depth of the production well is reached, perform logging of the geological formations to determine the amount of oil and gas present from inside the drill pipe of the drill string. This typically involves measurements from inside the drill string of the necessary geophysical quantities summarized in Item "b" of "Several Recent Changes in the Industry." The term 'Measurement-While-Drilling ("MWD")' is a term that is also defined in the '521 patent.

Lesson 3 of the series entitled "Lessons in Well Servicing and Workover", previously incorporated by reference in the '521 patent, on page v, lists entire chapters on the following subjects: "Electric Logging", "Acoustic Logging", "Nuclear Logging", "Temperature Logging", "Production Logging", and "Computer-generated Logging".

That Lesson 3 of the series entitled "Lessons in Well Servicing and Workover", on pages 4-5, states the following: "In general, three types of wireline log are available: electrical, acoustic, and nuclear. Electric logs measure natural and induced electrical properties of formations; acoustic, or sonic, logs measure the time it takes for sound to travel through a formation; and nuclear logs measure natural and induced radiation in formations. These measurements are interpreted to reveal the presence of oil, gas and water, the porosity of a formation, and many other characteristics pertinent to completing or recompleting a well successfully." Lesson 3 further states the following on pages 4-5: "In addition to electric, acoustic, and nuclear logs, other wireline logging devices are widely utilized. For example, caliper logs, which measure wellbore diameter, use flexible mechanical arms with pads that contact

the wall of the hole. Directional and dipmeter surveys, determine hole angle, direction, and formation dip, using mechanical and electrical measurements." Lesson 3 further states the following on pages 4-5: "Wireline logging tools are designed for running either in open hole or in cased hole." Lesson 3 further states the following on pages 4-5: "Cased-hole logging is accomplished after the casing is set in the hole."

Lesson 3 of the series entitled "Lessons in Well Servicing and Workover" on page 44, in the Glossary, defines "logging devices" as follows: "any of several electrical, acoustical, mechanical, or nuclear devices that are used to measure and record certain characteristics or events that occur in a well that has been or is being drilled". For the purposes herein, the term "logging means" is defined to include any "logging device". The term "measurement while drilling (MWD)" was previously defined above. Lesson 3 of the series entitled "Lessons in Well Servicing and Workover", on page 44, defines the term "Logging while drilling (LWD)" to be the following: "logging measurements obtained by measurement-while-drilling techniques as the well is being drilled."

As explained above, logging devices may be lowered into a drill string, geophysical data obtained from within the drill string, and then the logging devices removed, and rotary drilling begun again. In this way, geophysical data may be obtained from within a drill string. In one preferred embodiment, geophysical data may be obtained from within a nonrotating drill string. The geophysical data, or geophysical quantities, otherwise also called geophysical parameters, may be measured with sensors that are within the appropriate logging device. Accordingly, a logging device

possesses a geophysical parameter sensing member. Such a geophysical parameter sensing member may also be defined herein as a geophysical parameter sensing means or simply, as a geophysical sensing means. Geophysical parameter sensing members are used within the drill string shown in Figure 1 to obtain the appropriate geophysical quantities. In one preferred embodiment of the invention, the drill string is not rotating while the geophysical parameter sensing members are used to obtain the appropriate geophysical quantities. In one embodiment, the geophysical parameter sensing member obtains its information from within the drill string. Put another way, the geophysical parameter sensing member obtains its information from within steel pipe, be it drill pipe, or casing. In one preferred embodiment herein, the geophysical parameter sensing member does not obtain its information in the open borehole. An important element of a preferred embodiment of the invention is the method of obtaining all geophysical data from within a steel pipe that is necessary to determine the amount of oil and gas located adjacent to the steel pipe located in a geological formation.

In relation to Figures 1, 1A, 1B, and 1C, element 46 shows a drill string having a casing portion for lining the wellbore. In relation to Figures 1, 1A, 1B, and 1C, the term "earth removal member" has been defined. For example, as previously defined above, in relation to Figure 1, an example of an earth removal member is element 6 which is attached to the Latching Subassembly 18, which is in turn attached to the relatively thin-wall casing, or drill pipe, designated as element 46 in that Figure 1. In one embodiment, the Latching Subassembly 18 is defined for the purposes herein to be a drilling assembly. Hence, this Figure 1, and Figures 1A, 1B, and 1C, show a drilling assembly operatively connected to the drill string and having an earth removal member. When the

logging device, which possess a geophysical parameter sensing member, is inserted into element 46, then that assembled apparatus is an example of a drilling assembly operatively connected to the drill string and having an earth removal member and a geophysical parameter sensing member. Figure 1 shows an apparatus for drilling a wellbore. Accordingly, a preferred embodiment of the invention is an apparatus for drilling a wellbore comprising: a drill string having a casing portion for lining the wellbore; a drilling assembly operatively connected to the drill string and having an earth removal member and a geophysical parameter sensing member.

Accordingly, another preferred embodiment of the invention is the previously described apparatus further comprising a latching float collar valve means which, after the removal of the geophysical parameter sensing member from the wellbore, is pumped from the surface of the earth through the drill string with drilling mud so as to seat the latching float collar valve means above the earth removal member.

In accordance with the above, yet another preferred embodiment of the invention includes ceasing rotary drilling with the drill string on at least one occasion, introducing into the drill string a logging device having at least one geophysical parameter sensing member, measuring at least one geophysical parameter with the geophysical parameter sensing member, and removing the logging device from the drill string.

In accordance with the above, yet another preferred embodiment of the invention is a rotary drilling apparatus to drill a borehole into the earth comprising a hollow drill string, possessing at least one geophysical parameter sensing member, attached to a rotary drill bit having at least one

mud passage for passing the drilling mud from within the hollow drill string to the borehole, a source of drilling mud, a source of cement, and at least one latching float collar valve means that is pumped with the drilling mud into place above the rotary drill bit to install the latching float collar means within the hollow drill string above the rotary drill bit that is used to cement the drill string and rotary drill bit into the earth during one pass into the formation of the drill string to make a steel cased well.

In accordance with the above, yet another preferred embodiment of the invention is a method of drilling a well from the surface of the earth and cementing a drill string into place within a wellbore to make a cased well during one pass into formation using an apparatus comprising at least a hollow drill string, possessing at least one geophysical parameter sensing member, attached to a rotary drill bit, the bit having at least one mud passage to convey drilling mud from the interior of the drill string to the wellbore, a source of drilling mud, a source of cement, and at least one latching float collar valve assembly means, using at least the following steps: (a) pumping the latching float collar valve means from the surface of the earth through the hollow drill string with drilling mud so as to seat the latching float collar valve means above the drill bit; and (b) pumping cement through the seated latching float collar valve means to cement the drill string and rotary drill bit into place within the wellbore, whereby the geophysical parameter sensing member is used to measure at least one geophysical parameter from within the drill string.

A preferred embodiment of the invention is to allow the cement in the annulus between the drill pipe and the hole to cure under ambient hydrostatic conditions. In this preferred

embodiment, the cement sets up under these ambient hydrostatic conditions. As described above, this allows the cement to properly cure.

Unit II, Lesson 4, of the Rotary Drilling Series, an entire copy of which was incorporated into the '521 patent, on page 38, defines a "cement slurry". That Unit II, Lesson 4, on pages 41-42 further defines "Oilwell Cements and Additives", "API Classes of Cement", "Class A", "Class B", "Class C", "Class D", "Class E", "Class F", "Class G", "Class H", and "Class J". That Unit II, Lesson 4, on pages 43-44, further describes "Additives", "Retarders", "Accelerants", "Dispersants", and "Heavyweight Additives". That Unit II, Lesson 4, on pages 46-47, further describes "Lightweight additives", "Extenders", "Bridging materials", "Other additives", a "slurry", "Thixotropic cement", "Pozzolan cement", and "Expanding Cement". These different materials are all examples of "physically alterable bonding materials". These are also examples of "physically alterable bonding means". They bond between the casing and the annulus. So, they are a bonding materials. These materials also physically change their state from a liquid to a solid. Consequently, these diverse materials may be properly defined as a group to be "physically alterable bonding materials". These physically alterable bonding materials are placed in the annulus between the casing and the wellbore and allowed to cure.

There are other examples of embodiments of "physically alterable bonding materials". For example, U.S. Patent No. 3,960,801 that issued on June 1, 1976, that is entitled "Pumpable Epoxy Resin Composition", an entire copy of which is incorporated herein by reference, describes using epoxy resin compounds that cure to "a hard impermeable solid" in

subterranean formations. As another example, U.S. Patent No. 4,489,785 that issued on December 25, 1984, that is entitled "Method of Completing a Well Bore Penetrating Subterranean Formation", an entire copy of which is incorporated herein by reference, also describes using epoxy resins to form a "substantially crack-free, impermeable solid" in subterranean formations. As yet another example, U.S. Patent No. 5,159,980 that issued on November 3, 1992, that is entitled "Well Completion and Remedial Methods Utilizing Rubber Latex Compositions", an entire copy of which is incorporated herein by reference, describes making a "solid rubber plug or seal" in a subterranean geological formation. These materials also physically change their state from a liquid to a solid. Consequently, these materials may be defined as "physically alterable bonding materials". These physically alterable bonding materials are placed in the annulus between the casing and the wellbore and allowed to cure. These "physically alterable bonding materials" are examples of "physically alterable bonding means" or "physically alterable bonding material means" which are terms defined herein. For the purposes of this invention, the terms "physically alterable bonding materials", "physically alterable bonding means", and "physically alterable bonding material means" may be used interchangeably.

Unit I, Lesson 3, of the Rotary Drilling Series, an entire copy of which was incorporated within the '521 patent, on page 40, in the Glossary, defines "tubular goods" to be the following: "any kind of pipe, also called a tubular. Oil field tubular goods including tubing, casing, drill pipe, and line pipe." Previous description related to Figure 1 has described a method for lining a wellbore with a casing portion, that is element 46, in Figure 1. Therefore, in

accordance with the definition of a tubular, a method for lining a wellbore with a tubular has been described in relation to Figure 1.

As previously described above, in Figure 1, elements 6, 18 and 46 may comprise a drill string. The casing portion of that drill string is shown as element 46 in Figure 1. Therefore, description in relation to Figure 1 has described drilling the wellbore using a drill string, the drill string having a casing portion. Previous disclosure above in relation to Figure 1 has described locating the casing portion within the wellbore. Previous disclosure in relation to Figure 1 has described placing cement in an annulus formed between the casing portion (46) and the wellbore (2). The term "physically alterable bonding material" has been defined above. Therefore, Figure 1 and the related disclosure has provided a method of placing a physically alterable bonding material in an annulus formed between the casing portion and the wellbore.

A portion of the above specification states the following: 'As the water pressure is reduced on the inside of the drill pipe, then the cement in the annulus between the drill pipe and the hole can cure under ambient hydrostatic conditions. This procedure herein provides an example of the proper operation of a "one-way cement valve means".' Therefore, methods have been described in relation to Figure 1 for establishing a hydrostatic pressure condition in the wellbore and allowing the cement to cure under the hydrostatic pressure condition. In relation to the definition of a physically alterable bonding material, therefore, methods have been described in relation to Figure 1 for establishing a hydrostatic pressure condition

in the wellbore, and allowing the bonding material to physically alter under the hydrostatic pressure condition.

Accordingly, a preferred embodiment of the invention is a method for lining a wellbore with a tubular comprising: drilling the wellbore using a drill string, the drill string having a casing portion; locating the casing portion within the wellbore; placing a physically alterable bonding material in an annulus formed between the casing portion and the wellbore; establishing a hydrostatic pressure condition in the wellbore; and allowing the bonding material to physically alter under the hydrostatic pressure condition.

Put another way, the above embodiment has described a method for lining a wellbore with a tubular having at least the following steps: drilling the wellbore using a drill string attached to an earth removal member, the drill string having a casing portion; locating the casing portion within the wellbore; placing a physically alterable bonding material in an annulus formed between the casing portion and the wellbore; establishing a hydrostatic pressure condition in the wellbore; and allowing the bonding material to physically alter under the hydrostatic pressure condition.

In accordance with the above, methods have been described to allow physically alterable bonding material to cure thereby encapsulating the drill string in the wellbore with cured bonding material. In accordance with the above, methods have been described for encapsulating the drill string and rotary drill bit within the borehole with cured bonding material during one pass into formation. In accordance with the above, methods have been described for pumping physically alterable bonding material through a float collar valve means to encapsulate a drill string and rotary

drill bit with cured bonding material within the wellbore. In accordance with the above, methods have been described for encapsulating the drill string and rotary drill bit within the borehole with a physically alterable bonding material and allowing the bonding material to cure.

Unit III, Lesson 2, of the Rotary Drilling Series, previously incorporated by reference into the '521 patent, on page 1, describes a "retrieved cable-tool bit". Lesson 8 of the series entitled "Lessons in Well Servicing and Workover", previously incorporated by reference in the '521 patent, on page 23 describes an "underreamer" that may be used as a retrievable bit during drilling. In one embodiment of the present invention, the underreamer may be used as a retrievable bit during casing drilling. Page 23 of Unit III, Lesson 2, of the Rotary Drilling Series further states in relation to an underreamer: "...similar to an underreamer in that the cutters can be expanded by hydraulic pressure". Lesson 8 in this series further describes on page 15 a "retrievable packer" and in relation to Figure 21 on that page 15, also describes a "Retrievable Squeeze Tool".

There are other examples of retrievable elements used in the oil and gas industry. Lesson 4 of the series entitled "Lessons in Well Servicing and Workover", previously incorporated by reference in the '521 patent, on page 30, describes a "retrievable collar". Lesson 1 of the series entitled "Lessons in Well Servicing and Workover", previously incorporated by reference in the '521 patent, on page 22 describes "how a crew retrieves a sucker rod pump"; on page 24 describes "Rod String Retrieval" and "Tubing Retrieval"; and on page 27, describes a "Retrievable production packer".

In Figure 1, milled tooth rotary drill bit 6 is attached to Latching Subassembly 18 and Latching Float Collar Valve Assembly 20 is located within the Latching Subassembly. The Latching Float Collar Valve Assembly may be selectively retrieved following cementing operations. So, a selectively removable assembly (for example, the Latching Float Collar Valve Assembly 18) is connected to the drill bit 6 by a mechanical means (for example, the Latching Float Collar Valve Assembly 20). In one preferred embodiment of the invention, these elements comprise a drilling assembly. Accordingly, in relation to Figure 1, the above has described one embodiment of a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

In another preferred embodiment of the invention, the Upper Seal 22 of the Latching Float Collar Valve Assembly can be replaced with a solid, retrievable plug. That solid retrievable plug is designated with element 5, but is not shown in Figure 1 in the interest of brevity. After the Latching Float Collar Valve Assembly is pumped downhole with the solid retrievable plug in place, the solid retrievable plug may be suitably retrieved from the well before cementing operations are commenced. As yet another preferred embodiment of the invention, a retrievable wiper plug can be placed in the wellbore above Upper Seal 22 that is used to force down the Latching Float Collar Valve Assembly using hydraulic pressure applied in the wellbore. An example of such a wiper plug is the wiper plug that is generally shown as element 604 in Figure 15. Upper wiper attachment apparatus 606 may be used to retrieve the wiper plug. Wiper attachment apparatus 606 may be retrieved by Retrieval Sub 308 of a Smart Shuttle 306 as shown in Figure 8. Accordingly, in relation to Figure 1, the above has described an

embodiment of a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

In a preferred embodiment of the invention described herein, a drilling assembly comprises at least the following fundamental elements: (a) a drill bit; (b) a portion of the drilling assembly that is selectively removable from the wellbore without removing the casing; and (c) mechanical means connecting the drill bit to the selectively removable portion of the drilling assembly. This is an example of a "drilling assembly means". During drilling, measurements are taken by geophysical measurement means and drilling assembly means are used to cause the wellbore to be drilled. In a preferred embodiment herein, the geophysical measurement means are not a portion of the drilling assembly means. The word "selectively" means that the portion of the drilling assembly may be removed at will, and other objects may be removed from the wellbore at different times (such as a logging tool or other geophysical measurement means). In a preferred embodiment of the invention, a logging tool or other geophysical measurement means removed from the well is not a portion of the drilling assembly selectively removed from the well. In this embodiment, removing any drill bit from the well is not an example of a selectively removable portion of a drilling assembly because the drilling assembly must be physically attached to a drill bit. The preferred embodiment described by elements (a), (b), and (c) may be succinctly described as "drilling assembly means having selectively removable portion means". Such means allow the well to be drilled faster and more economically.

As another preferred embodiment, the pump-down wiper plugs and the pump-down one-way valves may also be removed

from the wellbore after they are cemented in place using analogous techniques that are described in Lesson 8 of the series entitled "Well Servicing and Workover", previously incorporated by reference within the '521 patent, with an overshoot tool of the variety shown in Figure 30 on page 22. Accordingly, in relation to Figure 1, the above has described an embodiment of a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

Figure 1 shows an apparatus for drilling a wellbore. In relation to Figure 1, and to Figures 1A, 1B, and 1C, element 46 has been previously described above as showing a drill string having a casing portion for lining the wellbore. Figure 1, and Figures 1A, 1B, and 1C, have previously been described above as showing a drilling assembly operatively connected to the drill string and having an earth removal member.

Accordingly, Figure 1, and Figures 1A, 1B, and 1C, show a preferred embodiment of the invention that is an apparatus for drilling a wellbore comprising: a drill string having a casing portion for lining the wellbore; and a drilling assembly operatively connected to the drill string and having an earth removal member; a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

Another preferred embodiment of the invention is the apparatus in the previous paragraph further comprising a latching float collar valve means which, following removal of the portion of the drilling assembly from the wellbore, is pumped from the surface of the earth through the drill

string with drilling mud so as to seat the latching float collar valve means above the earth removal member.

Figures 1, 1A, 1B, and 1C also show an embodiment of an apparatus for drilling a wellbore comprising: a drill string having a casing portion for lining the wellbore; and a drilling assembly selectively connected to the drill string and having an earth removal member.

Accordingly, a preferred embodiment of the invention is a method of making a cased wellbore comprising assembling a lower segment of a drill string comprising in sequence from top to bottom a first hollow segment of drill pipe, a drilling assembly means having a selectively removable portion and a rotary drill bit, the rotary drill bit having at least one mud passage for passing drilling mud from the interior of the drill string to the outside of the drill string; and after the predetermined depth is reached, retrieving the selectively removable portion of the drilling assembly from the wellbore, and pumping a latching float collar valve means down the interior of the drill string with drilling mud until it seats into place within the drilling assembly means.

In accordance with the above, a preferred embodiment of the invention is a rotary drilling apparatus to drill a borehole into the earth comprising a hollow drill string possessing a drilling assembly means having a selectively removable portion and a rotary drill bit, the rotary drill bit having at least one mud passage for passing the drilling mud from within the hollow drill string to the borehole, a source of drilling mud, a source of cement, and at least one latching float collar valve means whereby, after the total depth of the borehole is reached, and after retrieving the

removable portion from the wellbore, the latching float collar valve means is pumped with the drilling mud into place above the rotary drill bit to install the latching float collar means within the hollow drill string above the rotary drill bit that is used to cement the drill string and rotary drill bit into the earth during one pass into the formation of the drill string to make a steel cased well.

In view of the above, another preferred embodiment of the invention is a method of drilling a well from the surface of the earth and cementing a drill string into place within a wellbore to make a cased well during one pass into formation using an apparatus comprising at least a hollow drill string possessing a drilling assembly means having a selectively removable potion and a rotary drill bit, the drill bit having at least one mud passage to convey drilling mud from the interior of the drill string to the wellbore, a source of drilling mud, a source of cement, and at least one latching float collar valve assembly means, using at least the following steps: (a) after the total depth of the borehole is reached, retrieving the retrievable portion from the wellbore; (b) thereafter pumping the latching float collar valve means from the surface of the earth through the hollow drill string with drilling mud so as to seat the latching float collar valve means above the drill bit; and (c) thereafter pumping cement through the seated latching float collar valve means to cement the drill string and rotary drill bit into place within the wellbore.

Another preferred embodiment of the invention provides a float and float collar valve assembly permanently installed within the Latching Subassembly at the beginning of the drilling operations. However, such a preferred embodiment has the disadvantage that drilling mud passing by the float

and the float collar valve assembly during normal drilling operations could subject the mutually sealing surfaces to potential wear. Nevertheless, a float collar valve assembly can be permanently installed above the drill bit before the drill bit enters the well.

Permanently Installed One-Way Valve

Figure 2 shows another preferred embodiment of the invention that has such a float collar valve assembly permanently installed above the drill bit before the drill bit enters the well. Figure 2 shows many elements common to Figure 1. The Permanently Installed Float Collar Valve Assembly 76, hereinafter abbreviated as the "PIFCVA", is installed into the drill string on the surface of the earth before the drill bit enters the well. On the surface, the threads 16 on the rotary drill bit 6 are screwed into the lower female threads 78 of the PIFCVA. The bottom male threads of the drill pipe 48 are screwed into the upper female threads 80 of the PIFCVA. The PIFCVA Latching Sub Recession 82 is similar in nature and function to element 60 in Figure 1. The fluids flowing thorough the standard water passage 14 of the drill bit flow through PIFCVA Guide Channel 84. The PIFCVA Float 86 has a Hardened Hemispherical Surface 88 that seats against the hardened PIFCVA Float Seating Surface 90 under the force PIFCVA Spring 92. Surfaces 88 and 90 may be fabricated from very hard materials such as tungsten carbide. Alternatively, any hardening process in the metallurgical arts may be used to harden the surfaces of standard steel parts to make suitable hardened surfaces 88 and 90. The lower surfaces of the PIFCVA Spring 92 seat against the upper portion of the PIFCVA Threaded Spacer 94 that has PIFCVA Threaded Spacer Passage 96. The PIFCVA

Threaded Spacer 94 has exterior threads that thread into internal threads 100 of the PIFCVA (that is assembled into place within the PIFCVA prior to attachment of the drill bit to the PIFCVA). Surface 102 facing the lower portion of the PIFCVA Guide Channel 84 may also be made from hardened materials, or otherwise surface hardened, so as to prevent wear from the mud flowing through this portion of the channel during drilling.

Once the PIFCVA is installed into the drill string, then the drill bit is lowered into the well and drilling commenced. Mud pressure from the surface opens PIFCVA Float 86. The steps for using the preferred embodiment in Figure 2 are slightly different than using that shown in Figure 1. Basically, the "Steps 7 - 11 (Revised)" of the "New Drilling Process" are eliminated because it is not necessary to pump down any type of Latching Float Collar Valve Assembly of the type described in Figure 1. In "Steps 3 - 5 (Revised)" of the "New Drilling Process", it is evident that the PIFCVA is installed into the drill string instead of the Latching Subassembly appropriate for Figure 1. In Steps 12 - 13 (Revised) of the "New Drilling Process", it is also evident that the Lower Lobe of the Bottom Wiper Plug 58 latches into place into the PIFCVA Latching Sub Recession 82.

The PIFCVA installed into the drill string is another example of a one-way cement valve means installed near the drill bit to be used during one pass drilling of the well. Here, the term "near" shall mean within 500 feet of the drill bit. Consequently, Figure 2 describes a rotary drilling apparatus to drill a borehole into the earth comprising a drill string attached to a rotary drill bit and one-way cement valve means installed near the drill bit to cement the drill string and rotary drill bit into the earth to make a

steel cased well. Here, in this preferred embodiment, the method of drilling the borehole is implemented with a rotary drill bit having mud passages to pass mud into the borehole from within a steel drill string that includes at least one step that passes cement through such mud passages to cement the drill string into place to make a steel cased well.

The drill bits described in Figure 1 and Figure 2 are milled steel toothed roller cone bits. However, any rotary bit can be used with the invention. A tungsten carbide insert roller cone bit can be used. Any type of diamond bit or drag bit can be used. The invention may be used with any drill bit described in Ref. 3 above that possesses mud passages, waterpassages, or passages for gas. Any type of rotary drill bit can be used possessing such passageways. Similarly, any type of bit whatsoever that utilizes any fluid or gas that passes through passageways in the bit can be used whether or not the bit rotates.

As another example of "..any type of bit whatsoever.." described in the previous sentence, a new type of drill bit invented by the inventor of this application can be used for the purposes herein that is disclosed in U.S. Patent No. 5,615,747, that is entitled "Monolithic Self Sharpening Rotary Drill Bit Having Tungsten Carbide Rods Cast in Steel Alloys", that issued on April 1, 1997 (hereinafter Vail{747}), an entire copy of which is incorporated herein by reference. That new type of drill bit is further described in a Continuing Application of Vail{747} that is now U.S. Patent No. 5,836,409, that is also entitled "Monolithic Self Sharpening Rotary Drill Bit Having Tungsten Carbide Rods Cast in Steel Alloys", that issued on the date of November 17, 1998 (hereinafter Vail{409}), an entire copy of which is incorporated herein by reference. That new type

of drill bit is further described in a Continuation-in-Part Application of Vail{409} that is Serial No. 09/192,248, that has the filing date of 11/16/1998, that is now U.S. Patent No. 6,547,017, which issued on 4/15/2003 (hereinafter Vail{017}) which is entitled "Rotary Drill Bit Compensating for Changes in Hardness of Geological Formations", an entire copy of which is incorporated herein by reference. That new type of drill bit is further described in a Continuation in Part Application of Vail{017} that is Serial No. 10/413,101, having the filing date of 4/14/2003, that is also entitled "Rotary Drill Bit Compensating for Changes in Hardness of Geological Formations". As yet another example of "..any type of bit whatsoever.." described in the last sentence of the previous paragraph, Figure 3 shows the use of the invention using coiled-tubing drilling techniques.

Coiled Tubing Drilling

Figure 3 shows another preferred embodiment of the invention that is used for certain types of coiled-tubing drilling applications. Figure 3 shows many elements common to Figure 1. It is explicitly stated at this point that all the standard coiled-tubing drilling arts now practiced in the industry are incorporated herein by reference. Not shown in Figure 3 is the coiled tubing drilling rig on the surface of the earth having among other features, the coiled tubing unit, a source of mud, mud pump, etc. In Figure 3, the well has been drilled. This well can be: (a) a freshly drilled well; or (b) a well that has been sidetracked to a geological formation from within a casing string that is an existing cased well during standard re-entry applications; or (c) a well that has been sidetracked from within a tubing string that is in turn suspended within a casing string in

an existing well during certain other types of re-entry applications. Therefore, regardless of how drilling is initially conducted, in an open hole, or from within a cased well that may or may not have a tubing string, the apparatus shown in Figure 3 drills a borehole 2 through the earth including through geological formation 4.

Before drilling commences, the lower end of the coiled tubing 104 is attached to the Latching Subassembly 18. The bottom male threads of the coiled tubing 106 thread into the female threads of the Latching Subassembly 50.

The top male threads 108 of the Stationary Mud Motor Assembly 110 are screwed into the lower female threads 112 of Latching Subassembly 18. Mud under pressure flowing through channel 113 causes the Rotating Mud Motor Assembly 114 to rotate in the well. The Rotating Mud Motor Assembly 114 causes the Mud Motor Drill Bit Body 116 to rotate. In a preferred embodiment, elements 110, 114 and 116 are elements comprising a mud-motor drilling apparatus. That Mud Motor Drill Bit Body holds in place milled steel roller cones 118, 120, and 122 (not shown for simplicity). A standard water passage 124 is shown through the Mud Motor Drill Bit Body. During drilling operations, as mud is pumped down from the surface, the Rotating Mud Motor Assembly 114 rotates causing the drilling action in the well. It should be noted that any fluid pumped from the surface under sufficient pressure that passes through channel 113 goes through the mud motor turbine (not shown) that causes the rotation of the Mud Motor Drill Bit Body and then flows through standard water passage 124 and finally into the well.

The steps for using the preferred embodiment in Figure 3 are slightly different than using that shown in Figure 1. In

drilling an open hole, "Steps 3 - 5 (Revised)" of the "New Drilling Process" must be revised here to site attachment of the Latching Subassembly to one end of the coiled tubing and to site that standard coiled tubing drilling methods are employed. The coiled tubing can be on the coiled tubing unit at the surface for this step or the tubing can be installed into a wellhead on the surface for this step. In "Step 6 (Revised)" of the "New Drilling Process", measurements are to be performed from within the coiled tubing when it is disposed in the well. In "Steps 12 -13 (Revised)" of the "New Drilling Process", the Bottom Wiper Plug and the Top Wiper Plug are introduced into the upper end of the coiled tubing at the surface. The coiled tubing can be on the coiled tubing unit at the surface for these steps or the tubing can be installed into a wellhead on the surface for these steps. In sidetracking from within an existing casing, in addition to the above steps, it is also necessary to lower the coiled tubing drilling apparatus into the cased well and drill through the casing into the adjacent geological formation at some predetermined depth. In sidetracking from within an existing tubing string suspended within an existing casing string, it is also necessary to lower the coiled tubing drilling apparatus into the tubing string and then drill through the tubing string and then drill through the casing into the adjacent geological formation at some predetermined depth.

Therefore, Figure 3 shows a tubing conveyed mud motor drill bit apparatus to drill a borehole into the earth having a tubing attached to a mud motor driven rotary drill bit. A one-way cement valve means installed above the drill bit is used to cement the drill string and rotary drill bit into the earth to make a tubing encased well. The tubing conveyed mud motor drill bit apparatus is also called a tubing conveyed

mud motor drilling apparatus, that is also called a tubing conveyed mud motor driven rotary drill bit apparatus. Put another way, Figure 3 shows a section view of a coiled tubing conveyed mud motor driven rotary drill bit apparatus in the process of being cemented into place during one drilling pass into formation. This apparatus is cemented into place by using a Latching Float Collar Valve Assembly that has been pumped into place above the rotary drill bit. Methods of operating the tubing conveyed mud motor drilling apparatus in Figure 3 include a method of drilling a borehole with a coiled tubing conveyed mud motor driven rotary drill bit having mud passages to pass mud into the borehole from within the tubing that includes at least one step that passes cement through the mud passages to cement the tubing into place to make a tubing encased well.

In the "New Drilling Process", Step 14 is to be repeated, and that step is quoted in part in the following paragraph as follows:

> 'Step 14. Follow normal "final completion operations" that include installing the tubing with packers and perforating the casing near the producing zones. For a description of such normal final completion operations, please refer to the book entitled "Well Completion Methods", Well Servicing and Workover, Lesson 4, from the series entitled "Lessons in Well Servicing and Workover", Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1971 (hereinafter defined as "Ref. 2"), an entire copy of which is incorporated herein by reference. All of the individual definitions of words and phrases in the Glossary of Ref. 2 are also explicitly and separately incorporated herein in their entirety by reference. Other methods of

completing the well are described therein that shall, for the purposes of this application herein, also be called "final completion operations".'

With reference to the last sentence above, there are indeed many 'Other methods of completing the well that for the purposes of this application herein, also be called "final completion operations"'. For example, Ref. 2 on pages 10-11 describe "Open-Hole Completions". Ref. 2 on pages 13-17 describe "Liner Completions". Ref. 2 on pages 17-30 describe "Perforated Casing Completions" that also includes descriptions of centralizers, squeeze cementing, single zone completions, multiple zone completions, tubingless completions, multiple tubingless completions, and deep well liner completions among other topics.

Similar topics are also discussed in a previously referenced book entitled "Testing and Completing", Unit II, Lesson 5, Second Edition, of the Rotary Drilling Series, Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1983 (hereinafter defined as "Ref. 4"), an entire copy of which is incorporated herein by reference. All of the individual definitions of words and phrases in the Glossary of Ref. 1 are also explicitly and separately incorporated herein in their entirety by reference.

For example, on page 20 of Ref. 4, the topic "Completion Design" is discussed. Under this topic are described various different "Completion Methods". Page 21 of Ref. 4 describes "Open-hole completions". Under the topic of "Perforated completion" on pages 20-22, are described both standard cementing completions and gravel completions using slotted liners.

Well Completions with Slurry Materials

Standard cementing completions are described above in the new "New Drilling Process". However, it is evident that any slurry like material or "slurry material" that flows under pressure, and behaves like a multicomponent viscous liquid like material, can be used instead of "cement" in the "New Drilling Process". In particular, instead of "cement", water, gravel, or any other material can be used provided it flows through pipes under suitable pressure.

At this point, it is useful to review several definitions that are routinely used in the industry. First, the glossary of Ref. 4 defines several terms of interest.

The Glossary of Ref. 4 defines the term "to complete a well" to be the following: "to finish work on a well and bring it to productive status. See well completion."

The Glossary of Ref. 4 defines the term "well completion" to be the following: "1. the activities and methods of preparing a well for the production of oil and gas; the method by which one or more flow paths for hydrocarbons is established between the reservoir and the surface. 2. the systems of tubulars, packers, and other tools installed beneath the wellhead in the production casing, that is, the tool assembly that provides the hydrocarbon flow path or paths." To be precise for the purposes herein, the term "completing a well" or the term "completing the well" are each separately equivalent to performing all the necessary steps for a "well completion".

The Glossary of Ref. 4 defines the term "gravel" to be the following: "in gravel packing, sand or glass beads of

uniform size and roundness."

The Glossary of Ref. 4 defines the term "gravel packing" to be the following: "a method of well completion in which a slotted or perforated liner, often wire-wrapper, is placed in the well and surrounded by gravel. If open-hole, the well is sometimes enlarged by underreaming at the point were the gravel is packed. The mass of gravel excludes sand from the wellbore but allows continued production."

Other pertinent terms are defined in Ref. 1.

The Glossary of Ref. 1 defines the term "cement" to be the following: "a powder, consisting of alumina, silica, lime, and other substances that hardens when mixed with water. Extensively used in the oil industry to bond casing to walls of the wellbore."

The Glossary of Ref. 1 defines the term "cement clinker" to be the following: "a substance formed by melting ground limestone, clay or shale, and iron ore in a kiln. Cement clinker is ground into a powdery mixture and combined with small accounts of gypsum or other materials to form a cement".

The Glossary of Ref. 1 defines the term "slurry" to be the following: "a plastic mixture of cement and water that is pumped into a well to harden; there it supports the casing and provides a seal in the wellbore to prevent migration of underground fluids."

The Glossary of Ref. 1 defines the term "casing" as is typically used in the oil and gas industries to be the following: "steel pipe placed in an oil or gas well as

drilling progresses to prevent the wall of the hole from caving in during drilling, to prevent seepage of fluids, and to provide a means of extracting petroleum if the well is productive". Of course, in light of the invention herein, the "drill pipe" becomes the "casing", so the above definition needs modification under certain usages herein.

U.S. Patent No. 4,883,125, that issued on 11/28/1994, that is entitled "Cementing Oil and Gas Wells Using Converted Drilling Fluid", an entire copy of which is incorporated herein by reference, describes using "a quantity of drilling fluid mixed with a cement material and a dispersant such as a sulfonated styrene copolymer with or without an organic acid". Such a "cement and copolymer mixture" is yet another example of a "slurry material" for the purposes herein.

U.S. Patent No. 5,343,951, that issued on 9/6/1994, that is entitled "Drilling and Cementing Slim Hole Wells", an entire copy of which is incorporated herein by reference, describes "a drilling fluid comprising blast furnace slag and water" that is subjected thereafter to an activator that is "generally, an alkaline material and additional blast furnace slag, to produce a cementitious slurry which is passed down a casing and up into an annulus to effect primary cementing." Such an "blast furnace slag mixture" is yet another example of a "slurry material" for the purposes herein.

Therefore, and in summary, a "slurry material" may be any one, or more, of at least the following substances as rigorously defined above: cement, gravel, water, cement clinker, a "slurry" as rigorously defined above, a "cement and copolymer mixture", a "blast furnace slag mixture", and/or any mixture thereof. Virtually any known substance

that flows under sufficient pressure may be defined the purposes herein as a "slurry material".

Therefore, in view of the above definitions, it is now evident that the "New Drilling Process" may be performed with any "slurry material". The slurry material may be used in the "New Drilling Process" for open-hole well completions; for typical cemented well completions having perforated casings; and for gravel well completions having perforated casings; and for any other such well completions.

Accordingly, a preferred embodiment of the invention is the method of drilling a borehole with a rotary drill bit having mud passages for passing mud into the borehole from within a steel drill string that includes at least the one step of passing a slurry material through those mud passages for the purpose of completing the well and leaving the drill string in place to make a steel cased well.

Further, another preferred embodiment of the inventions is the method of drilling a borehole into a geological formation with a rotary drill bit having mud passages for passing mud into the borehole from within a steel drill string that includes at least one step of passing a slurry material through the mud passages for the purpose of completing the well and leaving the drill string in place following the well completion to make a steel cased well during one drilling pass into the geological formation.

Yet further, another preferred embodiment of the invention is a method of drilling a borehole with a coiled tubing conveyed mud motor driven rotary drill bit having mud passages for passing mud into the borehole from within the tubing that includes at the least one step of passing a

slurry material through the mud passages for the purpose of completing the well and leaving the tubing in place to make a tubing encased well.

And further, yet another preferred embodiment of the invention is a method of drilling a borehole into a geological formation with a coiled tubing conveyed mud motor driven rotary drill bit having mud passages for passing mud into the borehole from within the tubing that includes at least the one step of passing a slurry material through the mud passages for the purpose of completing the well and leaving the tubing in place following the well completion to make a tubing encased well during one drilling pass into the geological formation.

Yet further, another preferred embodiment of the invention is a method of drilling a borehole with a rotary drill bit having mud passages for passing mud into the borehole from within a steel drill string that includes at least steps of: attaching a drill bit to the drill string; drilling the well with the rotary drill bit to a desired depth; and completing the well with the drill bit attached to the drill string to make a steel cased well.

Still further, another preferred embodiment of the invention is a method of drilling a borehole with a coiled tubing conveyed mud motor driven rotary drill bit having mud passages for passing mud into the borehole from within the tubing that includes at least the steps of: attaching the mud motor driven rotary drill bit to the coiled tubing; drilling the well with the tubing conveyed mud motor driven rotary drill bit to a desired depth; and completing the well with the mud motor driven rotary drill bit attached to the drill string to make a steel cased well.

And still further, another preferred embodiment of the invention is the method of one pass drilling of a geological formation of interest to produce hydrocarbons comprising at least the following steps: attaching a drill bit to a casing string; drilling a borehole into the earth to a geological formation of interest; providing a pathway for fluids to enter into the casing from the geological formation of interest; completing the well adjacent to the formation of interest with at least one of cement, gravel, chemical ingredients, mud; and passing the hydrocarbons through the casing to the surface of the earth while the drill bit remains attached to the casing.

The term "extended reach boreholes" is a term often used in the oil and gas industry. For example, this term is used in U.S. Patent No. 5,343,950, that issued September 6, 1994, having the Assignee of Shell Oil Company, that is entitled "Drilling and Cementing Extended Reach Boreholes". An entire copy of U.S. Patent No. 5,343,950 is incorporated herein by reference. This term can be applied to very deep wells, but most often is used to describe those wells typically drilled and completed from offshore platforms. To be more explicit, those "extended reach boreholes" that are completed from offshore platforms may also be called for the purposes herein "extended reach lateral boreholes". Often, this particular term, "extended reach lateral boreholes", implies that substantial portions of the wells have been completed in one more or less "horizontal formation". The term "extended reach lateral borehole" is equivalent to the term "extended reach lateral wellbore" for the purposes herein. The term "extended reach borehole" is equivalent to the term "extended reach wellbore" for the purposes herein. The invention herein is particularly useful to drill and complete "extended reach wellbores" and "extend reach lateral wellbores".

Therefore, the preferred embodiments above generally disclose the one pass drilling and completion of wellbores with drill bit attached to drill string to make cased wellbores to produce hydrocarbons. The preferred embodiments above are also particularly useful to drill and complete "extended reach wellbores" and "extended reach lateral wellbores".

For methods and apparatus particularly suitable for the one pass drilling and completion of extended reach lateral wellbores please refer to **Figure 4.** Figure 4 shows another preferred embodiment of the invention that is closely related to Figure 3. Those elements numbered in sequence through element number 124 have already been defined previously. In Figure 4, the previous single "Top Wiper Plug 64" in Figures 1, 2, and 3 has been removed, and instead, it has been replaced with two new wiper plugs, respectively called "Wiper Plug A" and "Wiper Plug B". Wiper Plug A is labeled with numeral 126, and Wiper Plug A has a bottom surface that is defined as the Bottom Surface of Wiper Plug A that is numeral 128. The Upper Plug Seal of Wiper Plug A is labeled with numeral 130, and as it is shown in Figure 4, is not ruptured. The Upper Plug Seal of Wiper Plug A that is numeral 130 functions analogously to elements 54 and 56 of the Upper Seal of the Bottom Wiper Plug 52 that are shown in ruptured conditions in Figures 1, 2 and 3.

In Figure 4, Wiper Plug B is labeled with numeral 132. It has a lower surface that is called the "Bottom Surface of Wiper Plug B" that is labeled with numeral 134. Wiper Plug A and Wiper Plug B are introduced separately into the interior of the tubing to pass multiple slurry materials into the wellbore to complete the well.

Using analogous methods described above in relation to Figures 1, 2, and 3, water 136 in the tubing is used to push on Wiper Plug B (element 132), that in turn pushes on cement 138 in the tubing, that in turn is used to push on gravel 140, that in turn pushes on the Float 32, that in turn forces gravel into the wellbore past Float 32, that in turn forces mud 142 upward in the annulus of the wellbore. An explicit boundary between the mud and gravel is shown in the annulus of the wellbore in Figure 4, and that boundary is labeled with numeral 144.

After the Bottom Surface of Wiper Plug A that is element 128 positively "bottoms out" on the Top Surface 74 of the Bottom Wiper Plug, then a predetermined amount of gravel has been injected into the wellbore forcing mud 142 upward in the annulus. Thereafter, forcing additional water 136 into the tubing will cause the Upper Plug Seal of Wiper Plug A (element 130) to rupture, thereby forcing cement 138 to flow toward the Float 32. Forcing yet additional water 136 into the tubing will in turn cause the Bottom Surface of Wiper Plug B 134 to "bottom out" on the Top Surface of Wiper Plug A that is labeled with numeral 146. At this point in the process, mud has been forced upward in the annulus of wellbore by gravel. The purpose of this process is to have suitable amounts of gravel and cement placed sequentially into the annulus between the wellbore for the completion of the tubing encased well and for the ultimate production of oil and gas from the completed well. This process is particularly useful for the drilling and completion of extended reach lateral wellbores with a tubing conveyed mud motor drilling apparatus to make tubing encased wellbores for the production of oil and gas.

It is clear that Figure 1 could be modified with suitable Wiper Plugs A and B as described above in relation to Figure 4. Put simply, in light of the disclosure above, Figure 4 could be suitably altered to show a rotary drill bit attached to lengths of casing. However, in an effort to be brief, that detail will not be further described. Instead, Figure 5 shows one "snapshot" in the one pass drilling and completion of an extended reach lateral wellbore with drill bit attached to the drill string that is used to produce hydrocarbons from offshore platforms. This figure was substantially disclosed in U.S. Disclosure Document No. 452648 that was filed on March 5, 1999.

Extended Reach Lateral Wellbores

In **Figure 5**, an offshore platform 148 has a rotary drilling rig 150 surrounded by ocean 152 that is attached to the bottom of the sea 154. Riser 156 is attached to blowout preventer 158. Surface casing 160 is cemented into place with cement 162. Other conductor pipe, surface casing, intermediate casings, liner strings, or other pipes may be present, but are not shown for simplicity. The drilling rig 150 has all typical components of a normal drilling rig as defined in the figure entitled "The Rig and its Components" opposite of page 1 of the book entitled "The Rotary Rig and Its Components", Third Edition, Unit I, Lesson 1, that is part of the "Rotary Drilling Series" published by the Petroleum Extension Service, Division of Continuing Education, The University of Texas at Austin, Austin, Texas, 1980, 39 pages, and entire copy of which is incorporated herein by reference.

Figure 5 shows that oil bearing formation 164 has been drilled into with rotary drill bit 166. The oil bearing formation is in the earth below the ocean bottom. Drill bit 166 is attached to a "Completion Sub" having the appropriate float collar valve assembly, or other suitable float collar device, or which has one or more suitable latch recessions such as element 24 in Figure 1 for the purposes previously described, and which has other suitable completion devices as required that are shown in Figures 1, 2, 3, and 4. That "Completion Sub" is labeled with numeral 168 in Figure 5. Completion Sub 168 is in turn attached to many lengths of drill pipe, or casing as appropriate, one of which is labeled with numeral 170 in Figure 5. The drill pipe is supported by usual drilling apparatus provided by the drilling rig. Such drilling apparatus provides an upward force at the surface labeled with legend "F" in Figure 5, and the drill string is turned with torque provided by the drilling apparatus of the drilling rig, and that torque is figuratively labeled with the legend "T" in Figure 5.

The previously described methods and apparatus were used to first, in sequence, force gravel 172 in the portion of the oil bearing formation 164 having producible hydrocarbons. If required, a cement plug formed by a "squeeze job" is figuratively shown by numeral 174 in Figure 5 to prevent contamination of the gravel. Alternatively, an external casing packer, or other types of controllable packer means may be used for such purposes as previously disclosed by applicant in U.S. Disclosure Document No. 445686, filed on October 11, 1998. Yet further, the cement plug 174 can be pumped into place ahead of the gravel using the above procedures using yet another wiper plug as may be required.

The cement 176 introduced into the borehole through the mud passages of the drill bit using the above defined methods and apparatus provides a seal near the drill bit, among other locations, that is desirable under certain situations.

Slots in the drill pipe have been opened after the drill pipe reached final depth. The slots can be milled with a special milling cutter having thin rotating blades that are pushed against the inside of the pipe. As an alternative, standard perforations may be fabricated in the pipe using standard perforation guns of the type typically used in the industry. Yet further, special types of expandable pipe may be manufactured that when pressurized from the inside against a cement plug near the drill bit or against a solid strong wiper plug, or against a bridge plug, suitable slots are forced open. Or, different materials may be used in solid slots along the length of steel pipe when the pipe is fabricated that can be etched out with acid during the well completion process to make the slots and otherwise leaving the remaining steel pipe in place. Accordingly, there are many ways to make the required slots. One such slot is labeled with numeral 178 in Figure 5, and there are many such slots.

Therefore, hydrocarbons in zone 164 are produced through gravel 172 that flows through slots 178 and into the interior of the drill pipe to implement the one pass drilling and completion of an extended reach lateral wellbore with drill bit attached to drill string to produce hydrocarbons from an offshore platform. For the purposes of this preferred embodiment, such a completion is called a "gravel pack" completion, whether or not cement 174 or cement 176 are introduced into the wellbore.

It should be noted that in some embodiments, cement is not necessarily needed, and the formations may be "gravel pack" completed, or may be open-hole completed. In some situations, the float, or the one-way valve, need not be required depending upon the pressures in the formation.

Figure 5 also shows a zone that has been cemented shut with a "squeeze job", a term known in the industry representing perforating and then forcing cement into the annulus using suitable packers in order to cement certain formations. This particular cement introduced into the annulus of the wellbore in Figure 5 is shown as element 180. Such additional cementations may be needed to isolate certain formations as is typically done in the industry. As a final comment, the annulus 182 of the open hole 184 may otherwise be completed using typical well completion procedures in the oil and gas industries.

Therefore, Figure 5 and the above description discloses a preferred method of drilling an extended reach lateral wellbore from an offshore platform with a rotary drill bit having mud passages for passing mud into the borehole from within a steel drill string that includes at least one step of passing a slurry material through the mud passages for the purpose of completing the well and leaving the drill string in place to make a steel cased well to produce hydrocarbons from the offshore platform. As stated before, the term "slurry material" may be any one, or more, of at least the following substances: cement, gravel, water, "cement clinker", a "cement and copolymer mixture", a "blast furnace slag mixture", and/or any mixture thereof; or any known substance that flows under sufficient pressure.

Further, the above provides disclosure of a method of drilling an extended reach lateral wellbore from an offshore platform with a rotary drill bit having mud passages for passing mud into the borehole from within a steel drill string that includes at least the steps of passing sequentially in order a first slurry material and then a second slurry material through the mud passages for the purpose of completing the well and leaving the drill string in place to make a steel cased well to produce hydrocarbons from offshore platforms.

Yet another preferred embodiment of the invention provides a method of drilling an extended reach lateral wellbore from an offshore platform with a rotary drill bit having mud passages for passing mud into the borehole from within a steel drill string that includes at least the step of passing a multiplicity of slurry materials through the mud passages for the purpose of completing the well and leaving the drill string in place to make a steel cased well to produce hydrocarbons from the offshore platform.

It is evident from the disclosure in Figures 3 and 4, that a tubing conveyed mud motor drilling apparatus may replace the rotary drilling apparatus in Figure 5. Consequently, the above has provided another preferred embodiment of the invention that discloses the method of drilling an extended reach lateral wellbore from an offshore platform with a coiled tubing conveyed mud motor driven rotary drill bit having mud passages for passing mud into the borehole from within the tubing that includes at least one step of passing a slurry material through the mud passages for the purpose of completing the well and leaving the tubing in place to make a tubing encased well to produce hydrocarbons from the offshore platform.

And yet further, another preferred embodiment of the invention provides a method of drilling an extended reach lateral wellbore from an offshore platform with a coiled tubing conveyed mud motor driven rotary drill bit having mud passages for passing mud into the borehole from within the tubing that includes at least the steps of passing sequentially in order a first slurry material and then a second slurry material through the mud passages for the purpose of completing the well and leaving the tubing in place to make a tubing encased well to produce hydrocarbons from the offshore platform.

And yet another preferred embodiment of the invention discloses passing a multiplicity of slurry materials through the mud passages of the tubing conveyed mud motor driven rotary drill bit to make a tubing encased well to produce hydrocarbons from the offshore platform.

For the purposes of this disclosure, any reference cited above is incorporated herein in its entirely by reference herein. Further, any document, article, or book cited in any such above defined reference is also incorporated herein in its entirety by reference herein.

It should also be stated that the invention pertains to any type of drill bit having any conceivable type of passage way for mud that is attached to any conceivable type of drill pipe that drills to a depth in a geological formation wherein the drill bit is thereafter left at the depth when the drilling stops and the well is completed. Any type of drilling apparatus that has at least one passage way for mud that is attached to any type of drill pipe is also an embodiment of this invention, where the drilling apparatus specifically includes any type of rotary drill bit, any type

of mud driven drill bit, any type of hydraulically activated drill bit, or any type of electrically energized drill bit, or any drill bit that is any combination of the above. Any type of drilling apparatus that has at least one passage way for mud that is attached to any type of casing is also an embodiment of this invention, and this includes any metallic casing, any composite casing, and any plastic casing.
Any type of drill bit attached to any type of drill pipe, or pipe, made from any material is an embodiment of this invention, where such pipe includes a metallic pipe; a casing string; a casing string with any retrievable drill bit removed from the wellbore; a casing string with any drilling apparatus removed from the wellbore; a casing string with any electrically operated drilling apparatus retrieved from the wellbore; a casing string with any bicenter bit removed from the wellbore; a steel pipe; an expandable pipe; an expandable pipe made from any material; an expandable metallic pipe; an expandable metallic pipe with any retrievable drill bit removed from the wellbore; an expandable metallic pipe with any drilling apparatus removed from the wellbore; an expandable metallic pipe with any electrically operated drilling apparatus retrieved from the wellbore; an expandable metallic pipe with any bicenter bit removed from the wellbore; a plastic pipe; a fiberglass pipe; any type of composite pipe; any composite pipe that encapsulates insulated wires carrying electricity and/or any tubes containing hydraulic fluid; a composite pipe with any retrievable drill bit removed from the wellbore; a composite pipe with any drilling apparatus removed from the wellbore; a composite pipe with any electrically operated drilling apparatus retrieved from the wellbore; a composite pipe with any bicenter bit removed from the wellbore; a drill string; a drill string possessing a drill bit that remains attached to the end of the drill string after completing the wellbore;

a drill string with any retrievable drill bit removed from the wellbore; a drill string with any drilling apparatus removed from the wellbore; a drill string with any electrically operated drilling apparatus retrieved from the wellbore; a drill string with any bicenter bit removed from the wellbore; a coiled tubing; a coiled tubing possessing a mud-motor drilling apparatus that remains attached to the coiled tubing after completing the wellbore; a coiled tubing left in place after any mud-motor drilling apparatus has been removed; a coiled tubing left in place after any electrically operated drilling apparatus has been retrieved from the wellbore; a liner made from any material; a liner with any retrievable drill bit removed from the wellbore; a liner with any liner drilling apparatus removed from the wellbore; a liner with any electrically operated drilling apparatus retrieved from the liner; a liner with any bicenter bit removed from the wellbore; any other pipe made of any material with any type of drilling apparatus removed from the pipe; or any other pipe made of any material with any type of drilling apparatus removed from the wellbore. Any drill bit attached to any drill pipe that remains at depth following well completion is further an embodiment of this invention, and this specifically includes any retractable type drill bit, or retrievable type drill bit, that because of failure, or choice, remains attached to the drill string when the well is completed.

As had been referenced earlier, the above disclosure related to Figures 1-5 had been substantially repeated herein from Serial No. 09/295,808, now U.S. Patent 6,263,987 B1, and this disclosure is used so that the new preferred embodiments of the invention can be economically described in terms of those figures. It should also be noted that the following disclosure related to Figures 6, 7, 8, 9, 10, 11, 12, 13, 14,

15, 16, 17, and 18 is also substantially repeated herein from Serial No. 09/487,197, now U.S. Patent 6,397,946 B1.

Before describing those new features, perhaps a bit of nomenclature should be discussed at this point. In various descriptions of preferred embodiments herein described, the inventor frequently uses the designation of "one pass drilling", that is also called "One-Trip-Drilling" for the purposes herein, and otherwise also called "One-Trip-Down-Drilling" for the purposes herein.
For the purposes herein, a first definition of the phrases "one pass drilling", "One-Trip-Drilling", and "One-Trip-Down-Drilling" mean the process that results in the last long piece of pipe put in the wellbore to which a drill bit is attached is left in place after total depth is reached, and is completed in place, and oil and gas is ultimately produced from within the wellbore through that long piece of pipe. Of course, other pipes, including risers, conductor pipes, surface casings, intermediate casings, etc., may be present, but the last very long pipe attached to the drill bit that reaches the final depth is left in place and the well is completed using this first definition. This process is directed at dramatically reducing the number of steps to drill and complete oil and gas wells.

In accordance with the above, a preferred embodiment of the invention is a method of drilling a borehole from an offshore platform with a rotary drill bit having at least one mud passage for passing mud into the borehole from within a steel drill string comprising at least steps of:
(a) attaching a drill bit to the drill string; (b) drilling the well from the offshore platform with the rotary drill bit to a desired depth; and (c) completing the well with the drill bit attached to the drill string to make a steel cased

well. Such a method applies wherein the borehole is an extended reach wellbore and wherein the borehole is an extended reach lateral wellbore.

In accordance with the above, another preferred embodiment of the invention is a method of drilling a borehole from an offshore platform with a coiled tubing conveyed mud motor driven rotary drill bit having at least one mud passage for passing mud into the borehole from within the tubing comprising at least the steps of: (a) attaching the mud motor driven rotary drill bit to the coiled tubing; (b) drilling the well from the offshore platform with the tubing conveyed mud motor driven rotary drill bit to a desired depth; and (c) completing the well with the mud motor driven rotary drill bit attached to the drill string to make a steel cased well. Such a method applies wherein the borehole is an extended reach wellbore and wherein the borehole is an extended reach lateral wellbore.

In accordance with the above, another preferred embodiment of the invention is a method of one pass drilling from an offshore platform of a geological formation of interest to produce hydrocarbons comprising at least the following steps: (a) attaching a drill bit to a casing string located on an offshore platform; (b) drilling a borehole into the earth from the offshore platform to a geological formation of interest; (c) providing a pathway for fluids to enter into the casing from the geological formation of interest; (d) completing the well adjacent to the formation of interest with at least one of cement, gravel, chemical ingredients, mud; and (e) passing the hydrocarbons through the casing to the surface of the earth while the drill bit remains attached to the casing. Such a method applies wherein the borehole is an extended reach wellbore.

and wherein the borehole is an extended reach lateral wellbore.

In accordance with the above, another preferred embodiment of the invention is a method of drilling a borehole into a geological formation from an offshore platform using casing as at least a portion of the drill string and completing the well with the casing during one single drilling pass into the geological formation.

In accordance with the above, yet another preferred embodiment of the invention is a method of drilling a well from an offshore platform possessing a riser and a blowout preventer with a drill string, at least a portion of the drill string comprising casing, comprising at least the step of penetrating the riser and the blowout preventer with the drill string.

In accordance with the above, yet another preferred embodiment of the invention is a method of drilling a well from an offshore platform possessing a riser with a drill string, at least a portion of the drill string comprising casing, comprising at least the step of penetrating the riser with the drill string.

Please note that several steps in the One-Trip-Down-Drilling process had already been finished in Figure 5. However, it is instructive to take a look at one preferred method of well completion that leads to the configuration in Figure 5. Figure 6 shows one of the earlier steps in that preferred embodiment of well completion that leads to the configuration shown in Figure 5. Further, Figure 6 shows an embodiment of the invention that may be used with MWD/LWD measurements as described below.

Retrievable Instrumentation Packages

Figure 6 shows an embodiment of the invention that is particularly configured so that Measurement-While-Drilling (MWD) and Logging-While-Drilling (LWD) can be done during the drilling operations, but that following drilling operations employing MWD/LWD measurements, Smart Shuttles may be used thereafter to complete oil and gas production from the offshore platform using procedures and apparatus described in the following. Numerals 150 through 184 had been previously described in relation to Figure 5. In addition in Figure 6, the last section of standard drill pipe, or casing as appropriate, 186 is connected by threaded means to Smart Drilling and Completion Sub 188, that in turn is connected by threaded means to Bit Adaptor Sub 190, that is in turn connected by threaded means to rotary drill bit 192. As an option, this drill bit may be chosen by the operator to be a "Smart Bit" as described in the following.

The Smart Drilling and Completion Sub has provisions for many features. Many of these features are optional, so that some or all of them may be used during the drilling and completion of any one well. Many of those features are described in detail in U.S. Disclosure Document No. 452648 filed on March 5, 1999 that has been previously recited above. In particular, that U.S. Disclosure Document discloses the utility of "Retrievable Instrumentation Packages" that is described in detail in Figures 7 and 7A therein. Specifically, the preferred embodiment herein provides Smart Drilling and Completion Sub 188 that in turn surrounds the Retrievable Instrumentation Package 194 as shown in Figure 6.

As described in U.S. Disclosure Document No. 452648, to maximize the drilling distance of extended reach lateral drilling, a preferred embodiment of the invention possess the option to have means to perform measurements with sensors to sense drilling parameters, such as vibration, temperature, and lubrication flow in the drill bit - to name just a few. The sensors may be put in the drill bit 192, and if any such sensors are present, the bit is called a "Smart Bit" for the purposes herein. Suitable sensors to measure particular drilling parameters, particularly vibration, may also be placed in the Retrievable Instrumentation Package 194 in Figure 6. So, the Retrievable Instrumentation Package 194 may have "drilling monitoring instrumentation" that is an example of "drilling monitoring instrumentation means".

Any such measured information in Figure 6 can be transmitted to the surface. This can be done directly from the drill bit, or directly from any locations in the drill string having suitable electronic receivers and transmitters ("repeaters"). As a particular example, the measured information may be relayed from the Smart Bit to the Retrievable Instrumentation Package for final transmission to the surface. Any measured information in the Retrievable Instrumentation Package is also sent to the surface from its transmitter. As set forth in the above U.S. Disclosure Documents No. 452648, an actuator in the drill bit in certain embodiments of the invention can be controlled from the surface that is another optional feature of Smart Bit 192 in Figure 6. If such an actuator is in the drill bit, and/or if the drill bit has any type communication means, then the bit is also called a Smart Bit for the purposes herein. As various options, commands could be sent directly to the drill bit from the surface or may be relayed from the Retrievable Instrumentation Package to the drill bit. Therefore, the

Retrievable Instrumentation Package may have "drill bit control instrumentation" that is an example of a "drill bit control instrumentation means" which is used to control such actuators in the drill bit.

In one preferred embodiment of the invention, commands sent to any Smart Bit to change the configuration of the drill bit to optimize drilling parameters in Figure 6 are sent from the surface to the Retrievable Instrumentation Package using a "first communication channel" which are in turn relayed by repeater means to the rotary drill bit 192 that itself in this case is a "Smart Bit" using a "second communications channel". Any other additional commands sent from the surface to the Retrievable Instrumentation Package could also be sent in that "first communications channel". As another preferred embodiment of the invention, information sent from any Smart Bit that provides measurements during drilling to optimize drilling parameters can be sent from the Smart Bit to the Retrievable Instrumentation Package using a "third communications channel", which are in turn relayed to the surface from the Retrievable Instrumentation Package using a "fourth communication channel". Any other information measured by the Retrievable Instrumentation Package such as directional drilling information and/or information from MWD/LWD measurements would also be added to that fourth communications channel for simplicity. Ideally, the first, second, third, and fourth communications channels can send information in real time simultaneously. Means to send information includes acoustic modulation means, electromagnetic means, etc., that includes any means typically used in the industry suitably adapted to make the first, second, third, and fourth communications channels. In principle, any number of communications channels "N" can be used, all of which can be designed to function

simultaneously. The above is one description of a "communications instrumentation". Therefore, the Retrievable Instrumentation Package has "communications instrumentation" that is an example of "communications instrumentation means".

In a preferred embodiment of the invention the Retrievable Instrumentation package includes a "directional assembly" meaning that it possesses means to determine precisely the depth, orientation, and all typically required information about the location of the drill bit and the drill string during drilling operations. The "directional assembly" may include accelerometers, magnetometers, gravitational measurement devices, or any other means to determine the depth, orientation, and all other information that has been obtained during typical drilling operations. In principle this directional package can be put in many locations in the drill string, but in a preferred embodiment of the invention, that information is provided by the Retrievable Instrumentation Package. Therefore, the Retrievable Instrumentation Package has a "directional measurement instrumentation" that is an example of a "directional measurement instrumentation means".

As another option, and as another preferred embodiment, and means used to control the directional drilling of the drill bit, or Smart Bit, in Figure 6 can also be similarly incorporated in the Retrievable Instrumentation Package. Any hydraulic contacts necessary with formation can be suitably fabricated into the exterior wall of the Smart Drilling and Completion Sub 188. Therefore, the Retrievable Instrumentation Package may have "directional drilling control apparatus and instrumentation" that is an example of "directional drilling control apparatus and instrumentation means".

As an option, and as a preferred embodiment of the invention, the characteristics of the geological formation can be measured using the device in Figure 6. In principle, MWD ("Measurement-While-Drilling") or LWD ("Logging-While-Drilling") packages can be put in the drill string at many locations. In a preferred embodiment shown in Figure 6, the MWD and LWD electronics are made a part of the Retrievable Instrumentation Package inside the Smart Drilling and Completion Sub 188. Not shown in Figure 6, any sensors that require external contact with the formation such as electrodes to conduct electrical current into the formation, acoustic modulator windows to let sound out of the assembly, and other special windows suitable for passing natural gamma rays, gamma rays from spectral density tools, neutrons, etc., which are suitably incorporated into the exterior walls of the Smart Drilling and Completion Sub. Therefore, the Retrievable Instrumentation Package may have "MWD/LWD instrumentation" that is an example of "MWD/LWD instrumentation means".

Yet further, the Retrievable Instrumentation Package may also have active vibrational control devices. In this case, the "drilling monitoring instrumentation" is used to control a feedback loop that provides a command via the "communications instrumentation" to an actuator in the Smart Bit that adjusts or changes bit parameters to optimize drilling, and avoid "chattering", etc. See the article entitled "Directional drilling performance improvement", by M. Mims, World Oil, May 1999, pages 40-43, an entire copy of which is incorporated herein. Therefore, the Retrievable Instrumentation Package may also have "active feedback control instrumentation and apparatus to optimize drilling parameters" that is an example of "active feedback and

control instrumentation and apparatus means to optimize drilling parameters".

Therefore, the Retrieval Instrumentation Package in the Smart Drilling and Completion Sub in Figure 6 may have one or more of the following elements:

(a) mechanical means to pass mud through the body of 188 to the drill bit;

(b) retrieving means, including latching means, to accept and align the Retrievable Instrumentation Package within the Smart Drilling and Completion Sub;

(c) "drilling monitoring instrumentation" or "drilling monitoring instrumentation means";

(d) "drill bit control instrumentation" or "drill bit control instrumentation means";

(e) "communications instrumentation" or "communications instrumentation means";

(f) "directional measurement instrumentation" or "directional measurement instrumentation means";

(g) "directional drilling control apparatus and instrumentation" or "directional drilling control apparatus and instrumentation means";

(h) "MWD/LWD instrumentation" or "MWD/LWD instrumentation means" which provide typical geophysical measurements which include induction measurements, laterolog measurements, resistivity measurements,

dielectric measurements, magnetic resonance imaging measurements, neutron measurements, gamma ray measurements; acoustic measurements, etc.

(i) "active feedback and control instrumentation and apparatus to optimize drilling parameters" or "active feedback and control instrumentation and apparatus means to optimize drilling parameters";

(j) an on-board power source in the Retrievable Instrumentation Package or "on-board power source means in the Retrievable Instrumentation Package";

(k) an on-board mud-generator as is used in the industry to provide energy to (j) above or "mud-generator means".

(l) batteries as are used in the industry to provide energy to (j) above or "battery means";

For the purposes of this invention, any apparatus having one or more of the above features (a), (b), ..., (j), (k), or (l), AND which can also be removed from the Smart Drilling and Completion Sub as described below in relation to Figure 7, shall be defined herein as a Retrievable Instrumentation Package, that is an example of a retrievable instrument package means.

Figure 7 shows a preferred embodiment of the invention that is explicitly configured so that following drilling operations that employ MWD/LWD measurements of formation properties during those drilling operations, Smart Shuttles may be used thereafter to complete oil and gas production from the offshore platform. As in Figure 6, Smart Drilling and Completion Sub 188 has disposed inside it Retrievable

Instrumentation Package 194. The Smart Drilling and Completion Sub has mud passage 196 through it. The Retrievable Instrumentation Package has mud passage 198 through it. The Smart Drilling and Completion Sub has upper threads 200 that engage the last section of standard drill pipe, or casing as appropriate, 186 in Figure 6. The Smart Drilling and Completion Sub has lower threads 202 that engage the upper threads of the Bit Adaptor Sub 190 in Figure 6.

In Figure 7, the Retrievable Instrumentation Package has high pressure walls 204 so that instrumentation in the package is not damaged by pressure in the wellbore. It has an inner payload radius r1, an outer payload radius r2, and overall payload length L that are not shown for the purposes of brevity. The Retrievable Instrumentation Package has retrievable means 206 that allows a wireline conveyed device from the surface to "lock on" and retrieve the Retrievable Instrumentation Package. Element 206 is the "Retrieval Means Attached to the Retrievable Instrumentation Package".

As shown in Figure 7, the Retrievable Instrumentation Package may have latching means 208 that is disposed in latch recession 210 that is actuated by latch actuator means 212. The latching means 208 and latch recession 210 may function as described above in previous embodiments or they may be electronically controlled as required from inside the Retrievable Instrumentation Package.

Guide recession 214 in the Smart Drilling and Completion Sub is used to guide into place the Retrievable Instrumentation Package having alignment spur 216. These elements are used to guide the Retrievable Instrumentation Package into place and for other purposes as described below. These are examples of "alignment means".

Acoustic transmitter/receiver 218 and current conducting electrode 220 are used to measure various geological parameters as is typical in the MWD/LWD art in the industry, and they are "potted" in insulating rubber-like compounds 222 in the wall recession 224 shown in Figure 7. Various MWD/LWD measurements are provided by MWD/LWD instrumentation (by element 294 that is defined below) including induction measurements, laterolog measurements, resistivity measurements, dielectric measurements, magnetic resonance imaging measurements, neutron measurements, gamma ray measurements; acoustic measurements, etc. Power and signals for acoustic transmitter/receiver 218 and current conducting electrode 220 are sent over insulated wire bundles 226 and 228 to mating electrical connectors 232 and 234. Electrical connector 234 is a high pressure connector that provides power to the MWD/LWD sensors and brings their signals into the pressure free chamber within the Retrievable Instrumentation Package as are typically used in the industry. Geometric plane "A" "B" is defined by those legends appearing in Figure 7 for reasons which will be explained later.

A first directional drilling control apparatus and instrumentation is shown in Figure 7. Cylindrical drilling guide 236 is attached by flexible spring coupling device 238 to moving bearing 240 having fixed bearing race 242 that is anchored to the housing of the Smart Drilling and Completion Sub near the location specified by the numeral 244. Sliding block 246 has bearing 248 that makes contact with the inner portion of the cylindrical drilling guide at the location specified by numeral 250 that in turn sets the angle θ. The cylindrical drilling guide 236 is free to spin when it is in physical contact with the geological formation. So, during rotary drilling, the cylindrical drilling guide spins about

the axis of the Smart Drilling and Completion Sub that in turn rotates with the remainder of the drill string. The angle θ sets the direction in the x-y plane of the drawing in Figure 7. Sliding block 246 is spring loaded with spring 252 in one direction (to the left in Figure 7) and is acted upon by piston 254 in the opposite direction (to the right as shown in Figure 7). Piston 254 makes contact with the sliding block at the position designated by numeral 256 in Figure 7. Piston 254 passes through bore 258 in the body of the Smart Drilling and Completion Sub and enters the Retrievable Instrumentation Package through o-ring 260. Hydraulic piston actuator assembly 262 actuates the hydraulic piston 254 under electronic control from instrumentation within the Retrievable Instrumentation Package as described below. The position of the cylindrical drilling guide 236 and its angle θ is held stable in the two dimensional plane specified in Figure 7 by two competing forces described as (a) and (b) in the following: (a) the contact between the inner portion of the cylindrical drilling guide 236 and the bearing 248 at the location specified by numeral 250; and (b) the net "return force" generated by the flexible spring coupling device 238. The return force generated by the flexible spring coupling device is zero only when the cylindrical drilling guide 236 is parallel to the body of the Smart Drilling and Completion Sub.

There is a second such directional drilling control apparatus located rotationally 90 degrees from the first apparatus shown in Figure 7 so that the drill bit can be properly guided in all directions for directional drilling purposes. However, this second assembly is not shown in Figure 7 for the purposes of brevity. This second assembly sets the angle β in analogy to the angle θ defined above. The directional drilling apparatus in Figure 7 is one example

of "directional drilling control means". Directional drilling in the oil and gas industries is also frequently called "geosteering", particularly when geophysical information is used in some way to direct the direction of drilling, and therefore the apparatus in Figure 7 is also an example of a "geosteering means".

The elements described in the previous two paragraphs concerning Figure 7 provide an example of a directional drilling means. In this case, it is not necessary to periodically halt the rotary drilling so as to introduce into the wellbore directional surveying means because data is continuously sent uphole due to the existence of the "communications instrumentation" and the "directional measurement instrumentation" previously described above (and in the foregoing). Nor does this apparatus require a jet deflection bit to perform directional drilling.

When the Retrievable Instrumentation Package 194 has been removed from the Smart Drilling and Completion Sub 188, methods previously described in relation to Figures 1, 1A, 1B, 1C, and 1D may be used to complete the well. Accordingly, methods of operation have been described in relation to Figure 7 that provide an embodiment of the method of directional drilling a well from the surface of the earth and cementing a drill string into place within a wellbore to make a cased well during one pass into formation using an apparatus comprising at least a hollow drill string attached to a rotary drill bit possessing directional drilling means, the bit having at least one mud passage to convey drilling mud from the interior of the drill string to the wellbore, a source of drilling mud, a source of cement, and at least one latching float collar valve assembly means, using at least the following steps: (a) pumping the latching float collar

valve means from the surface of the earth through the hollow drill string with drilling mud so as to seat the latching float collar valve means above the drill bit; and (b) pumping cement through the seated latching float collar valve means to cement the drill string and rotary drill bit into place within the wellbore.

In relation to Figure 7, methods have been described for an embodiment for selectively causing a drilling trajectory to change during the drilling. In relation to Figure 6, element 170 provides an embodiment of the means for lining the wellbore with the casing portion. In the case of Figure 7, lower threads 202 engage the upper threads of Bit Adaptor Sub 190 in Figure 6 so that the rotary drill bit 192 in Figure 6 (an example of an earth removal member) is attached to Smart Drilling and Completion Sub 188. In Figure 6, the Smart Drilling and Completion Sub 188 is attached to standard drill pipe, or casing as appropriate, 186 by upper threads 200 in Figure 7. Therefore, the drill string has an earth removal member operatively connected thereto. Accordingly, Figures 1, 1A, 1B, 1C, 1D, 6 and 7, and their related description, have provided a method for drilling and lining a wellbore comprising drilling the wellbore using a drill string, the drill string having an earth removal member operatively connected thereto and a casing portion for lining the wellbore; selectively causing a drilling trajectory to change during the drilling; and lining the wellbore with the casing portion.

There are many other types of directional drilling means. For a general review of the status of developments on directional drilling control systems in the industry, and their related uses, particularly in offshore environments, please refer to the following references: (a) the article

entitled "ROTARY-STEERABLE TECHNOLOGY - Part 1, Technology gains momentum", by T. Warren, Oil and Gas Journal, 12/21/1998, pages 101-105, an entire copy of which is incorporated herein by reference; (b) the article entitled "ROTARY-STEERABLE TECHNOLOGY - Conclusion, Implementation issues concern operators", by T. Warren, Oil and Gas Journal, 12/28/1998, pages 80-83, an entire copy of which is incorporated herein by reference; (c) the entire issue of World Oil dated December 1998 entitled in part on the front cover "Marine Drilling Rigs, What's Ahead in 1999", an entire copy of which is incorporated herein by reference; (d) the entire issue of World Oil dated July 1999 entitled in part on the front cover "Offshore Report" and "New Drilling Technology", an entire copy of which is incorporated herein in by reference; and (e) the entire issue of The American Oil and Gas Reporter dated June 1999 entitled in part on the front cover "Offshore & Subsea Technology", an entire copy of which is incorporated herein by reference; (f) U.S. Patent No. 5,332,048, having the inventors of Underwood et. al., that issued on July 26, 1994 entitled in part "Method and Apparatus for Automatic Closed Loop Drilling System", an entire copy of which is incorporated herein by reference; (g) and U.S. Patent No. 5,842,149 having the inventors of Harrell et. al., that issued on November 24, 1998, that is entitled "Closed Loop Drilling System", an entire copy of which is incorporated herein by reference. Furthermore, all references cited in the above defined documents (a) and (b) and (c) and (d) and (e) and (f) and (g) in this paragraph are also incorporated herein in their entirety by reference. Specifically, all 17 references cited on page 105 of the article defined in (a) and all 3 references cited on page 83 of the article defined in (b) are incorporated herein by reference. For further reference, rotary steerable apparatus and rotary steerable

systems may also be called "rotary steerable means", a term defined herein. Further, all the terms that are used, or defined in the above listed references (a), (b), (c), (d), and (e) are incorporated herein in their entirety.

Figure 7 also shows a mud-motor electrical generator. The mud-motor generator is only shown FIGURATIVELY in Figure 7. This mud-motor electrical generator is incorporated within the Retrievable Instrumentation Package so that the mud-motor electrical generator is substantially removed when the Retrievable Instrumentation Package is removed from the Smart Drilling and Completion Sub. Such a design can be implemented using a split-generator design, where a permanent magnet is turned by mud flow, and pick-up coils inside the Retrievable Instrumentation Package are used to sense the changing magnetic field resulting in a voltage and current being generated. Such a design does not necessary need high pressure seals for turning shafts of the mud-motor electrical generator itself. To figuratively show a preferred embodiment of the mud-motor electrical generator in Figure 7, element 264 is a permanently magnetized turbine blade having magnetic polarity N and S as shown. Element 266 is another such permanently magnetized turbine blade having similar magnetic polarity, but the N and S are not marked on element 266 in Figure 7. These two turbine blades spin about a bearing at the position designated by numeral 268 where the two turbine blades cross in Figure 7. The details for the support of that shaft are not shown in Figure 7 for the purposes of brevity. The mud flowing through the mud passage 198 of the Retrievable Instrumentation Package causes the magnetized turbine blades to spin about the bearing at position 268. A pick-up coil mounted on magnetic bar material designated by numeral 270 senses the changing magnetic field caused by the spinning magnetized turbine

blades and produces electrical output 272 that in turn provides time varying voltage V(t) and time varying current I(t) to yet other electronics described below that is used to convert these waveforms into usable power as is required by the Retrievable Instrumentation Package. The changing magnetic field penetrates the high pressure walls 204 of the Retrievable Instrumentation Package. For the figurative embodiment of the mud-motor electrical generator shown in Figure 7, non-magnetic steel walls are probably better to use than walls made of magnetic materials. Therefore, the Retrievable Instrumentation Package and the Smart Drilling and Completion Sub may have a mud-motor electrical generator for the purposes herein.

The following block diagram elements are also shown in Figure 7: element 274, the electronic instrumentation to sense, accept, and align (or release) the "Retrieval Means Attached to the Retrievable Instrumentation Package" and to control the latch actuator means 212 during acceptance (or release); element 276, "power source" such as batteries and/or electronics to accept power from mud-motor electrical generator system and to generate and provide power as required to the remaining electronics and instrumentation in the Retrievable Instrumentation Package; element 278, "downhole computer" controlling various instrumentation and sensors that includes downhole computer apparatus that may include processors, software, volatile memories, non-volatile memories, data buses, analogue to digital converters as required, input/output devices as required, controllers, battery back-ups, etc.; element 280, "communications instrumentation" as defined above; element 282, "directional measurement instrumentation" as defined above; element 284, "drilling monitoring instrumentation" as defined above; element 286, "directional drilling control apparatus and

instrumentation" as defined above; element 288, "active feedback and control instrumentation to optimize drilling parameters", as defined above; element 290, general purpose electronics and logic to make the system function properly including timing electronics, driver electronics, computer interfacing, computer programs, processors, etc.; element 292, reserved for later use herein; and element 294 "MWD/LWD instrumentation", as defined above.

In Figure 7, geophysical quantities are continuously measured, and it is not necessary to introduce any separate logging device into the wellbore to perform measurements. Element 294 in Figure 7 is an embodiment of the "MWD/LWD instrumentation" that is defined above. Item (h) above defines "MWD/LWD instrumentation" or "MWD/LWD instrumentation means" as devices which provide typical geophysical measurements which include neutron measurements, gamma ray measurements and acoustic measurements. Each of these different devices may possess at least one geophysical parameter sensing member to measure at least one geophysical quantity. In a preferred embodiment of the invention described herein, each such geophysical quantity is obtained from measurements within a drill string or other metal housing. In a preferred embodiment of the invention described herein, the geophysical parameter sensing member obtains its information from within the drill string or other metal housing. In yet another embodiment of the invention, no information is obtained from the open borehole. In relation to Figures 6 and 7, the drill bit ("an earth removal member") is connected to a drilling assembly (element 190 in Figure 6 and element 188 in shown in Figures 6 and 7) that is operatively connected to the drill pipe, or the casing (elements 186 and 170 in Figure 6). Elements 192, 190, 188, 186, and 170 in Figure 6 provide an embodiment of a drill

string having a casing portion for lining the wellbore. The casing portion for lining the wellbore may comprise elements 186 and 170 in Figure 6. Accordingly, Figures 6 and 7 show an embodiment of an apparatus for drilling a wellbore comprising: a drill string having a casing portion for lining the wellbore; a drilling assembly operatively connected to the drill string and having an earth removal member and a geophysical parameter sensing member.

Figure 7 also shows optional mud seal 296 on the outer portion of the Retrievable Instrumentation Package that prevents drilling mud from flowing around the outer portion of that Package. Most of the drilling mud as shown in Figure 7 flows through mud passages 196 and 198. Mud seal 296 is shown figuratively only in Figure 7, and may be a circular mud ring, but any type of mud sealing element may be used, including the designs of elastomeric mud sealing elements normally associated with wiper plugs as described above and as used in the industry for a variety of purposes.

It should be evident that the functions attributed to the single Smart Drilling and Completion Sub 188 and Retrievable Instrumentation Package 194 may be arbitrarily assigned to any number of different subs and different pressure housings as is typical in the industry. However, "breaking up" the Smart Drilling and Completion Sub and the Retrievable Instrumentation Package are only minor variations of the preferred embodiment described herein.

Perhaps it is also worth noting that a primary reason for inventing the Retrievable Instrumentation Package 194 is because in the event of One-Trip-Down-Drilling, then the drill bit and the Smart Drilling and Completion Sub are left in the wellbore to save the time and effort to bring out the

drill pipe and replace it with casing. However, if the MWD/LWD instrumentation is used as in Figure 7, the electronics involved is often considered too expensive to abandon in the wellbore. Further, major portions of the directional drilling control apparatus and instrumentation and the mud-motor electrical generator are also relatively expensive, and those portions often need to be removed to minimize costs. Therefore, the Retrievable Instrumentation Package 194 is retrieved from the wellbore before the well is thereafter completed to produce hydrocarbons.

The preferred embodiment of the invention in Figure 7 has one particular virtue that is of considerable value. When the Retrievable Instrumentation Package 194 is pulled to the left with the Retrieval Means Attached to the Retrievable Instrumentation Package 206, then mating connectors 232 and 234 disengage, and piston 254 is withdrawn through the bore 258 in the body of the Smart Drilling and Completion Sub. The piston 254 had made contact with the sliding block 246 at the location specified by numeral 256, and when the Retrievable Instrumentation Package 194 is withdrawn, the piston 254 is free to be removed from the body of the Smart Drilling and Completion Sub. The Retrievable Instrumentation Package "splits" from the Smart Drilling and Completion Sub approximately along plane "A" "B" defined in Figure 7. In this way, most of the important and expensive electronics and instrumentation can be removed after the desired depth is reached. With suitable designs of the directional drilling control apparatus and instrumentation, and with suitable designs of the mud-motor electrical generator, the most expensive portions of these components can be removed with the Retrievable Instrumentation Package.

The preferred embodiment in Figure 7 has yet another important virtue. If there is any failure of the Retrievable Instrumentation Package before the desired depth has been reached, it can be replaced with another unit from the surface without removing the pipe from the well using methods to be described in the following. This feature would save considerable time and money that is required to "trip out" a standard drill string to replace the functional features of the instrumentation now in the Retrievable Instrumentation Package.

In any event, after the total depth is reached in Figure 6, and if the Retrievable Instrumentation Package had MWD and LWD measurement packages as described in Figure 7, then it is evident that sufficient geological information is available vs. depth to complete the well and to commence hydrocarbon production. Then, the Retrievable Instrumentation Package can be removed from the pipe using techniques to be described in the following.

It should also be noted that in the event that the wellbore had been drilled to the desired depth, but on the other hand, the MWD and LWD information had NOT been obtained from the Retrievable Instrumentation Package during that drilling, and following its removal from the pipe, then measurements of the required geological formation properties can still be obtained from within the steel pipe using the logging techniques described above under the topic of "Several Recent Changes in the Industry" - and please refer to item (b) under that category. Logging through steel pipes and logging through casings to obtain the required geophysical information are now possible.

In any event, let us assume that at this point in the One-Trip-Down-Drilling Process that the following is the situation: (a) the wellbore has been drilled to final depth; (b) the configuration is as shown in Figure 6 with the Retrievable Instrumentation Package at depth; and (c) complete geophysical information has been obtained with the Retrievable Instrumentation Package.

As described earlier in relation to Figure 7, the Retrievable Instrumentation Package has retrieval means 206 that allows a wireline conveyed device operated from the surface to "lock on" and retrieve the Retrievable Instrumentation Package. Element 206 is the "Retrieval Means Attached to the Retrievable Instrumentation Package" in Figure 7. As one form of the preferred embodiment shown in Figure 7, element 206 may have retrieval grove 298 that will assist the wireline conveyed device from the surface to "lock on" and retrieve the Retrievable Instrumentation Package.

As previously discussed above in relation to Figures 6 and 7, the drill string may include elements 192, 190, 188, 186 and 170. Element 192 has been previously described as an "earth removal member" that is attached to the Bit Adaptor Sub 190. The Smart Drilling and Completion Sub 188 surrounds the Retrievable Instrumentation Package 194. Element 194 as previously described contains geophysical measurement instrumentation or geophysical measurement means. Element 194 also contains directional drilling means comprised of elements 254, 258, 260 and 262. In a preferred embodiment of the invention, all the geophysical measurement instrumentation within element 194 is eliminated and the geophysical measurements are provided by separate logging tools placed into the drill string. Element 194 with all geophysical measurement instrumentation removed is defined as

element 195 herein. Element 195 is not shown in Figure 7 for the purposes of brevity. In a preferred embodiment, a drilling assembly does not possess geophysical measurement means. In one preferred embodiment, elements 188, 190, 192, and 195 comprise a drilling assembly. Therefore, element 195 is an example of a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

Elements 188, 190, 192, and 195 comprise an embodiment of a drilling assembly operatively connected to the drill string. A casing section of that drill string in a preferred embodiment includes elements 170 and 186. That casing section may be used as a casing portion for lining the wellbore. Therefore, Figures 6 and 7 show an embodiment of an apparatus for drilling a wellbore comprising a drill string having a casing portion for lining the wellbore. Further, in relation to Figures 6 and 7, an embodiment of an apparatus has been described that possesses a drilling assembly operatively connected to the drill string and having an earth removal member.

Element 195 is an example of a selectively removable portion of the drilling assembly. As described above, element 195 is selectively removable from the wellbore. The removal of element 195 does not require the removal of the casing portion 170 and 186. Accordingly, an embodiment of an apparatus has been described that has a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

In view of the above, a preferred embodiment of the invention is an apparatus for drilling a wellbore comprising: a drill string having a casing portion for lining the

wellbore; and a drilling assembly operatively connected to the drill string and having an earth removal member; a portion of the drilling assembly being selectively removable from the wellbore without removing the casing portion.

In view of the above, Figures 6 and 7 also show an embodiment of an apparatus for drilling a wellbore comprising: a drill string having a casing portion for lining the wellbore; and a drilling assembly selectively connected to the drill string and having an earth removal member.

When element 195 has been removed from the Smart Drilling and Completion Sub 188, methods previously described in relation to Figures 1, 1A, 1B, 1C, and 1D may be used to complete the well. The definition of a tubular has been defined in relation to Figure 1. Elements 170 and 186 in Figure 6 are examples of tubulars. Using previously described completion methods, Figures 6 and 7 provide a method for lining a wellbore with a tubular. As previously discussed in relation to Figure 6, the drill string may include elements 192, 190, 188, 186 and 170. A casing section of that drill string in a preferred embodiment includes elements 170 and 186. Therefore, in relation to Figures 6 and 7, methods are presented for drilling the wellbore using a drill string, the drill string having a casing portion. Figure 6 shows an embodiment of locating the casing portion (elements 170 and 186) within the wellbore. The phrase "physically alterable bonding material" has been defined in the specification related to Figure 1 and is used as a substitute for cement in previously described methods.

A portion of the above specification states the following: 'As the water pressure is reduced on the inside of the drill pipe, then the cement in the annulus between the

drill pipe and the hole can cure under ambient hydrostatic conditions. This procedure herein provides an example of the proper operation of a "one-way cement valve means".' Therefore, methods have been described in relation to Figure 1 for establishing a hydrostatic pressure condition in the wellbore and allowing the cement to cure under the hydrostatic pressure conditions. In relation to the definition of a physically alterable bonding material, therefore, methods have been described in relation to Figure 1 for establishing a hydrostatic pressure condition in the wellbore, and allowing the bonding material to physically alter under the hydrostatic pressure condition.

The above in relation to Figures 6 and 7 has therefore described a method for lining a wellbore with a tubular comprising: drilling the wellbore using a drill string, the drill string having a casing portion; locating the casing portion within the wellbore; placing a physically alterable bonding material in an annulus formed between the casing portion and the wellbore; establishing a hydrostatic pressure condition in the wellbore; and allowing the bonding material to physically alter under the hydrostatic pressure condition.

In accordance with the above in relation to Figures 6 and 7, methods have been described to allow physically alterable bonding material to cure thereby encapsulating the drill string in the wellbore with cured bonding material. In accordance with the above, methods have been described for encapsulating the drill string and rotary drill bit within the borehole with cured bonding material during one pass into formation. In accordance with the above, methods have been described for pumping physically alterable bonding material through a float collar valve means to encapsulate a drill

string and rotary drill bit with cured bonding material within the wellbore.

Smart Shuttles

Figure 8 shows an example of such a wireline conveyed device operated from the surface of the earth used to retrieve devices within the steel drill pipe that is generally designated by numeral 300. A wireline 302, typically having 7 electrical conductors with an armor exterior, is attached to the cablehead, generally labeled with numeral 304 in Figure 8. Cablehead 304 is in turn attached to the Smart Shuttle that is generally shown as numeral 306 in Figure 8, which in turn is connected to an attachment. In this case, the attachment is the "Retrieval & Installation Subassembly", otherwise abbreviated as the "Retrieval/Installation Sub", also simply abbreviated as the "Retrieval Sub", and it is generally shown as numeral 308 in Figure 8. The Smart Shuttle is used for a number of different purposes, but in the case of Figure 8, and in the sequence of events described in relation to Figures 6 and 7, it is now appropriate to retrieve the Retrievable Instrumentation Package installed in the drill string as shown in Figures 6 and 7. To that end, please note that electronically controllable retrieval snap ring assembly 310 is designed to snap into the retrieval grove 298 of element 206 when the mating nose 312 of the Retrieval Sub enters mud passage 198 of the Retrievable Instrumentation Package. Mating nose 312 of the Retrieval Sub also has retrieval sub electrical connector 313 (not shown in Figure 8) that provides electrical commands and electrical power received from the wireline and from the Smart Shuttle as is appropriate. (For the record, the retrieval sub electrical

connector 313 is not shown explicitly in Figure 8 because the scale of that drawing is too large, but electrical connector 313 is explicitly shown in Figure 9 where the scale is appropriate.)

Figure 8 shows a portion of an entire system to automatically complete oil and gas wells. This system is called the "Automated Smart Shuttle Oil and Gas Completion System", or also abbreviated as the "Automated Smart Shuttle System", or the "Smart Shuttle Oil and Gas Completion System". In Figure 8, the floor of the offshore platform 314 is attached to riser 156 having riser hanger apparatus 315 as is typically used in the industry. The drill pipe 170, or casing as appropriate, is composed of many lengths of drill pipe and a first blowout preventer 316 is suitably installed on an upper section of the drill pipe using typical art in the industry. This first blowout preventer 316 has automatic shut off apparatus 318 and manual back-up apparatus 319 as is typical in the industry. A top drill pipe flange 320 is installed on the top of the drill string.

The "Wiper Plug Pump-Down Stack" is generally shown as numeral 322 in Figure 8. The reason for the name for this assembly will become clear in the following. Wiper Plug Pump-Down Stack" 322 is comprised various elements including the following: lower pump-down stack flange 324, cylindrical steel pipe wall 326, upper pump-down stack flange 328, first inlet tube 330 with first inlet tube valve 332, second inlet tube 334 with second inlet tube valve 336, third inlet tube 338 with third inlet tube valve 340, with primary injector tube 342 with primary injector tube valve 344. Particular regions within the "Wiper Plug Pump-Down Stack" are identified respectively with legends A, B and C that are shown in Figure 8. Bolts and bolt patterns for the lower

pump-down stack flange 324, and its mating part that is top drill pipe flange 320, are not shown for simplicity. Bolts and bolt patterns for the upper pump down stack flange 328, and its respective mating part to be describe in the following, are also not shown for simplicity. In general in Figure 8, flanges may have bolts and bolt patterns, but those are not necessarily shown for the purposes of simplicity.

The "Smart Shuttle Chamber" 346 is generally shown in Figure 8. Smart Shuttle chamber door 348 is pressure sealed with a one-piece O-ring identified with the numeral 350. That O-ring is in a standard O-ring grove as is used in the industry. Bolt hole 352 through the Smart Shuttle chamber door mates with mounting bolt hole 354 on the mating flange body 356 of the Smart Shuttle Chamber. Tightened bolts will firmly hold the Smart Shuttle chamber door 348 against the mating flange body 356 that will suitably compress the one-piece O-ring 350 to cause the Smart Shuttle Chamber to seal off any well pressure inside the Smart Shuttle Chamber.

Smart Shuttle Chamber 346 also has first Smart Shuttle chamber inlet tube 358 and first Smart Shuttle chamber inlet tube valve 360. Smart Shuttle Chamber 346 also has second Smart Shuttle chamber inlet tube 362 and second Smart Shuttle chamber inlet tube valve 364. Smart Shuttle Chamber 346 has upper Smart Shuttle chamber cylindrical wall 366 and upper smart Shuttle Chamber flange 368 as shown in Figure 8. The Smart Shuttle Chamber 346 has two general regions identified with the legends D and E in Figure 8. Region D is the accessible region where accessories may be attached or removed from the Smart Shuttle, and region E has a cylindrical geometry below second Smart Shuttle chamber inlet tube 362. The Smart Shuttle and its attachments can be "pulled up" into region E from region D for various purposes

to be described later. Smart Shuttle Chamber 346 is attached by the lower Smart Shuttle flange 370 to upper pump-down stack flange 328. The entire assembly from the lower Smart Shuttle flange 370 to the upper Smart Shuttle chamber flange 368 is called the "Smart Shuttle Chamber System" that is generally designated with the numeral 372 in Figure 8. The Smart Shuttle Chamber System 372 includes the Smart Shuttle Chamber itself that is numeral 346 which is also referred to as region D in Figure 8.

The "Wireline Lubricator System" 374 is also generally shown in Figure 8. Bottom flange of wireline lubricator system 376 is designed to mate to upper Smart Shuttle chamber flange 368. These two flanges join at the position marked by numeral 377. In Figure 8, the legend Z shows the depth from this position 377 to the top of the Smart Shuttle. Measurement of this depth Z, and knowledge of the length L1 of the Smart Shuttle (not shown in Figure 8 for simplicity), and the length L2 of the Retrieval Sub (not shown in Figure 8 for simplicity), and all other pertinent lengths L3, L4,..., of any apparatus in the wellbore, allows the calculation of the "depth to any particular element in the wellbore" using standard art in the industry.

The Wireline Lubricator System in Figure 8 has various additional features, including a second blowout preventer 378, lubricator top body 380, fluid control pipe 382 and its fluid control valve 384, a hydraulic packing gland generally designated by numeral 386 in Figure 8, having gland sealing apparatus 388, grease packing pipe 390 and grease packing valve 392. Typical art in the industry is used to fabricate and operate the Wireline Lubricator System, and for additional information on such systems, please refer to Figure 9, page 11, of Lesson 4, entitled "Well Completion

Methods", of series entitled "Lessons in Well Servicing and Workover", published by the Petroleum Extension Service of The University of Texas at Austin, Austin, Texas, 1971, that is incorporated herein by reference in its entirety, which series was previously referred to above as "Ref. 2". In Figure 8, the upper portion of the wireline 394 proceeds to sheaves as are used in the industry and to a wireline drum under computer control as described in the following. However, at this point, it is necessary to further describe relevant attributes of the Smart Shuttle.

The Smart Shuttle shown as element 306 in Figure 8 is an example of "a conveyance means".

Figure 9 shows an enlarged view of the Smart Shuttle 306 and the "Retrieval Sub" 308 that are attached to the cablehead 304 suspended by wireline 302. The cablehead has shear pins 396 as are typical in the industry. A threaded quick change collar 398 causes the mating surfaces of the cablehead and the Smart Shuttle to join together at the location specified by numeral 400. Typically 7 insulated electrical conductors are passed through the location specified by numeral 400 by suitable connectors and O-rings as are used in the industry. Several of these wires will supply the needed electrical energy to run the electrically operated pump in the Smart Shuttle and other devices as described below.

In Figure 9, a particular embodiment of the Smart Shuttle is described which, in this case, has an electrically operated internal pump, and this pump is called the "internal pump of the Smart Shuttle" that is designated by numeral 402. Numeral 402 designates an "internal pump means". The upper inlet port 404 for the

pump has electronically controlled upper port valve 406. The lower inlet port 408 for the pump has electronically controlled lower port valve 410. Also shown in Figure 9 is the bypass tube 412 having upper bypass tube valve 414 and lower bypass tube valve 416. In a preferred embodiment of the invention, the electrically operated internal pump 402 is a "positive displacement pump". For such a pump, and if valves 406 and 410 are open, then during any one specified time interval Δt, a specific volume of fluid ΔV1 is pumped from below the Smart Shuttle to above the Smart Shuttle through inlets 404 and 408 as they are shown in Figure 9. For further reference, the "down side" of the Smart Shuttle in Figure 9 is the "first side" of the Smart Shuttle and the "up side" of the Smart Shuttle in Figure 9 is the "second side" of the Smart Shuttle. Such up and down designations loose their meaning when the wellbore is substantially a horizontal wellbore where the Smart Shuttle will have great utility. Please refer to the legends ΔV1 on Figure 9. This volume ΔV1 relates to the movement of the Smart Shuttle as described later below.

In Figure 9, the Smart Shuttle also has elastomer sealing elements. The elastomer sealing elements on the right-hand side of Figure 9 are labeled as elements 418 and 420. These elements are shown in a flexed state which are mechanically loaded against the right-hand interior cylindrical wall 422 of the Smart Shuttle Chamber 346 by the hanging weight of the Smart Shuttle and related components. The elastomer sealing elements on the left-hand side of Figure 9 are labeled as elements 424 and 426, and are shown in a relaxed state (horizontal) because they are not in contact with any portion of a cylindrical wall of the Smart Shuttle Chamber. These elastomer sealing elements are examples of "lateral sealing means" of the Smart Shuttle.

In the preferred embodiment shown in Figure 9, it is contemplated that the right-hand element 418 and the left-hand element 424 are portions of one single elastomeric seal. It is further contemplated that the right-hand element 420 and the left-hand element 426 are portions of yet another separate elastomeric seal. Many different seals are possible, and these are examples of "sealing means" associated with the Smart Shuttle.

Figure 9 further shows quick change collar 428 that causes the mating surfaces of the lower portion of the Smart Shuttle to join together to the upper mating surfaces of the Retrieval Sub at the location specified by numeral 430. Typically, 7 insulated electrical conductors are also passed through the location specified by numeral 430 by suitable mating electrical connectors as are typically used in the industry. Therefore, power, control signals, and measurements can be relayed from the Smart Shuttle to the Retrieval Sub and from the Retrieval Sub to the Smart Shuttle by suitable mating electrical connectors at the location specified by numeral 430. To be thorough, it is probably worthwhile to note here that numeral 431 is reserved to figuratively designate the top electrical connector of the Retrieval Sub, although that connector 431 is not shown in Figure 9 for the purposes of simplicity. The position of the electronically controllable retrieval snap ring assembly 310 is controlled by signals from the Smart Shuttle. With no signal, the snap ring of assembly 310 is spring-loaded into the position shown in Figure 9. With a "release command" issued from the surface, electronically controllable retrieval snap ring assembly 310 is retracted so that it does NOT protrude outside vertical surface 432 (i.e., snap ring assembly 310 is in its full retracted position). Therefore, electronic signals from the surface are used to control the

electronically controllable retrieval snap ring assembly 310, and it may be commanded from the surface to "release" whatever it had been holding in place. In particular, once suitably aligned, assembly 310 may be commanded to "engage" or "lock-on" retrieval grove 298 in the Retrievable Instrumentation Package 206, or it can be commanded to "release" or "pull back from" the retrieval grove 298 in the Retrievable Instrumentation Package as may be required during deployment or retrieval of that Package, as the case may be.

One method of operating the Smart Shuttle is as follows. With reference to Figure 8, and if the first Smart Shuttle chamber inlet tube valve 360 is in its open position, fluids, such as water or drilling mud as required, are introduced into the first Smart Shuttle chamber inlet tube 358. With second Smart Shuttle chamber inlet tube valve 364 in its open position, then the injected fluids are allowed to escape through second Smart Shuttle chamber inlet tube 362 until substantially all the air in the system has been removed. In a preferred embodiment, the internal pump of the Smart Shuttle 402 is a self-priming pump, so that even if any air remains, the pump will still pump fluid from below the Smart Shuttle, to above the Smart Shuttle. Similarly, inlets 330, 334, 338, and 342, with their associated valves, can also be used to "bleed the system" to get rid of trapped air using typical procedures often associated with hydraulic systems. With reference to Figure 9, it would further help the situation if valves 406, 410, 414 and 416 in the Smart Shuttle were all open simultaneously during "bleeding operations", although this may not be necessary. The point is that using typical techniques in the industry, the entire volume within the regions A, B, C, D, and E within the interior of the apparatus in Figure 8 can be fluid filled with fluids such as drilling mud, water, etc. This state of

affairs is called the "priming" of the Automated Smart Shuttle System in this preferred embodiment of the invention.

After the Automated Smart Shuttle System is primed, then the wireline drum is operated to allow the Smart Shuttle and the Retrieval Sub to be lowered from region D of Figure 8 to the part of the system that includes regions A, B, and C. Figure 10 shows the Smart Shuttle and Retrieval Sub in that location.

The Smart Shuttle shown as element 306 in Figure 9 is an example of "a conveyance means".

In **Figure 10**, all the numerals and legends in Figure 10 have been previously defined. When the Smart Shuttle and the Retrieval Sub are located in regions A, B, and C, then the elastomer sealing elements 418, 420, 424, and 426 positively seal against the cylindrical walls of the now fluid filled enclosure. Please notice the change in shape of the elastomer sealing elements 424 and 426 in Figure 9 and in Figure 10. The reason for this change is because the regions A, B, and C are bounded by cylindrical metal surfaces with intervening pipes such as inlet tubes 330, 334, 338, and primary injector tube 342. In a preferred embodiment of the invention, the vertical distance between elastomeric units 418 and 420 are chosen so that they do simultaneously overlap any two inlet pipes to avoid loss a positive seal along the vertical extent of the Smart Shuttle.

Then, in Figure 10, valves 414 and 416 are closed, and valves 406 and 410 are opened. Thereafter, the electrically operated internal pump 402 is turned "on". In a preferred embodiment of the invention, the electrically operated internal pump is a "positive displacement pump". For such a

pump, and as had been previously described, during any one specified time interval Δt, a specific volume of fluid $\Delta V1$ is pumped from below the Smart Shuttle to above the Smart Shuttle through valves 406 and 410. Please refer to the legends $\Delta V1$ on Figure 10. In Figure 10, The top of the Smart Shuttle is at depth Z, and that legend was defined in Figure 8 in relation to position 377 in that figure. In Figure 10, the inside radius of the cylindrical portion of the wellbore is defined by the legend a1. However, first it is perhaps useful to describe several different embodiments of Smart Shuttles and associated Retrieval Subs.

Element 306 in Figure 8 is the "Smart Shuttle". This apparatus is "smart" because the "Smart Shuttle" has one or more of the following features (hereinafter, "List of Smart Shuttle Features"):

(a) it can provide depth measurement information, ie., it can have "depth measurement means"

(b) it can provide orientation information within the metallic pipe, drill string, or casing, whatever is appropriate, including the angle with respect to vertical, and any azimuthal angle in the pipe as required, and any other orientational information required, ie., it can have "orientational information measurement means"

(c) it can possess at least one power source, such as a battery or batteries, or apparatus to convert electrical energy from the wireline to power any sensors, electronics, computers, or actuators as required, ie., it can have "power source means"

(d) it can possess at least one sensor and associated electronics including any required analogue to digital converter devices to monitor pressure, and/or temperature, such as vibrational spectra, shock sensors, etc., ie., it can have "sensor measurement means"

(e) it can receive commands sent from the surface, ie., it can have "command receiver means from surface"

(f) it can send information to the surface, ie., it can have "information transmission means to surface"

(g) it can relay information to one or more portions of the drill string, ie., it can have "tool relay transmission means"

(h) it can receive information from one or more portions of the drill string, ie., it can have "tool receiver means"

(i) it can have one or more means to process information, ie., it can have at least one "processor means"

(j) it can have one or more computers to process information, and/or interpret commands, and/or send data, ie., it can have one or more "computer means"

(k) it can have one or more means for data storage

(l) it can have one or more means for nonvolatile data storage if power is interrupted, ie., it can have one or more "nonvolatile data storage means"

(m) it can have one or more recording devices, ie., it can have one or more "recording means"

(n) it can have one or more read only memories, ie., it can have one or more "read only memory means"

(o) it can have one or more electronic controllers to process information, ie., it can have one or more "electronic controller means"

(p) it can have one or more actuator means to change at least one physical element of the device in response to measurements within the device, and/or commands received from the surface, and/or relayed information from any portion of the drill string

(q) the device can be deployed into a pipe of any type including a metallic pipe, a drill string, a composite pipe, a casing as is appropriate, by any means, including means to pump it down with mud pressure by analogy to a wiper plug, or it may use any type of mechanical means including gears and wheels to engage the casing, where such gears and wheels include any well tractor type device, or it may have an electrically operated pump and a seal, or it may be any type of "conveyance means"

(r) the device can be deployed with any coiled tubing device and may be retrieved with any coiled tubing device, ie., it can be deployed and retrieved with any "coiled tubing means"

(s) the device can be deployed with any coiled tubing device having wireline inside the coiled tubing device

(t) the device can have "standard depth control sensors", which may also be called "standard geophysical depth control sensors", including natural gamma ray measurement devices, casing collar locators, etc., ie., the device can have "standard depth control measurement means"

(u) the device can have any typical geophysical measurement device described in the art including its own MWD/LWD measurement devices described elsewhere above, ie., it can have any "geophysical measurement means"

(v) the device can have one or more electrically operated pumps including positive displacement pumps, turbine pumps, centrifugal pumps, impulse pumps, etc., ie., it can have one or more "internal pump means"

(w) the device can have a positive displacement pump coupled to a transmission device for providing relatively large pulling forces, ie., it can have one or more "transmission means"

(x) the device can have two pumps in one unit, a positive displacement pump to provide large forces and relatively slow Smart Shuttle speeds and a turbine pump to provide lesser forces at relatively high Smart Shuttle speeds, ie., it may have "two or more internal pump means"

(y) the device can have one or more pumps operated by other energy sources

(z) the device can have one or more bypass assemblies such as the bypass assembly comprised of elements 464, 466, 468, 470, and 472 in Figure 11, ie., it may have one or more "bypass means"

(aa) the device can have one or more electrically operated valves, ie., it can have one or more electrically operated "valve means"

(ab) it can have attachments to it, or devices incorporated in it, that install into the well and/or retrieve from the well various "Well Completion Devices" that are defined below

As mentioned earlier, a U.S. Trademark Application has been filed for the Mark "Smart Shuttle". This Mark has received a "Notice of Publication Under 12(a)" and it will be published in the Official Gazette on June 11, 2002. Under "LISTING OF GOODS AND/OR SERVICES" for the Mark "Smart Shuttle" it states: "oil and gas industry hydraulically driven or electrically driven conveyors to move equipment through onshore and offshore wells, cased wells, open-hole wells, pipes, tubings, expandable tubings, liners, cylindrical sand screens, and production flowlines; the conveyed equipment including well completion and production devices, logging tools, perforating guns, well drilling equipment, coiled tubings for well stimulation, power cables, containers of chemicals, and flowline cleaning equipment".

As mentioned earlier, a U.S. Trademark Application has been filed for the Mark "Smart Shuttle". This Mark has received a "Notice of Publication Under 12(a)" and it will be published in the Official Gazette on June 11, 2002. The

"LISTING OF GOODS AND/OR SERVICES" for Mark "Well Locomotive" is the same as for "Smart Shuttle".

The "Retrieval & Installation Subassembly", otherwise abbreviated as the "Retrieval/Installation Sub", also simply abbreviated as the "Retrieval Sub", which is generally shown as numeral 308, has one or more of the following features (hereinafter, "List of Retrieval Sub Features"):

(a) it can be attached to, or is made a portion of, the Smart Shuttle

(b) it can have means to retrieve apparatus disposed in a pipe made of any material

(c) it can have means to install apparatus into a pipe made of any material

(d) it can have means to install various completion devices into a pipe made of any material

(e) it can have means to retrieve various completion devices from a pipe made of any material

(f) it can have at least one sensor for measuring information downhole, and apparatus for transmitting that measured information to the Smart Shuttle or uphole, apparatus for receiving commands if necessary, and a battery or batteries or other suitable power source as may be required

(g) it can be attached to, or be made a portion of, a conveyance means such as a well tractor

(h) it can be attached to, or be made a portion of, any pump-down means of the types described later in this document

Element 402 that is the "internal pump of the Smart Shuttle" may be any electrically operated pump, or any hydraulically operated pump that in turn, derives its power in any way from the wireline. Standard art in the field is used to fabricate the components of the Smart Shuttle and that art includes all pump designs typically used in the industry. Standard literature on pumps, fluid mechanics, and hydraulics is also used to design and fabricate the components of the Smart Shuttle, and specifically, the book entitled "Theory and Problems of Fluid Mechanics and Hydraulics", Third Edition, by R.V. Giles, J.B. Evett, and C. Liu, Schaum's Outline Series, McGraw-Hill, Inc., New York, New York, 1994, 378 pages, is incorporated herein in its entirety by reference.

For the purposes of several preferred embodiments of this invention, an example of a "wireline conveyed smart shuttle means having retrieval and installation means" (also "wireline conveyed Smart Shuttle means having retrieval and installation means") is comprised of the Smart Shuttle and the Retrieval Sub shown in Figure 8. From the above description, a Smart Shuttle may have many different features that are defined in the above "List of Smart Shuttle Features" and the Smart Shuttle by itself is called for the purposes herein a "wireline conveyed smart shuttle means" (also "wireline conveyed Smart Shuttle means), or simply a "wireline conveyed shuttle means". A Retrieval Sub may have many different features that are defined in the above "List of Retrieval Sub Features" and for the purposes herein, it is also described as a "retrieval and installation means".

Accordingly, a particular preferred embodiment of a "wireline conveyed shuttle means" has one or more features from the "List of Smart Shuttle Features" and one or more features from the "List of Retrieval Sub Features". Therefore, any given "wireline conveyed shuttle means having retrieval and installation means" may have a vast number of different features as defined above. Depending upon the context, the definition of a "wireline conveyed smart shuttle means having retrieval and installation means" may include any first number of features on the "List of Smart Shuttle Features" and may include any second number of features on the "List of Retrieval Sub Features". In this context, and for example, a "wireline conveyed shuttle means having retrieval and installation means" may have 4 particular features on the "List of Smart Shuttle Features" and may have 3 features on the "List of Retrieval Sub Features". The phrase "wireline conveyed smart shuttle means having retrieval and installation means" is also equivalently described for the purposes herein as "wireline conveyed shuttle means possessing retrieval and installation means".

It is now appropriate to discuss a generalized block diagram of one type of Smart Shuttle. The block diagram of another preferred embodiment of a Smart Shuttle is identified as numeral 434 in **Figure 11**. Legends showing "UP" and "DOWN" appear in Figure 11. Element 436 represents a block diagram of a first electrically operated internal pump, and in this preferred embodiment, it is a positive displacement pump, which is associated with an upper port 438, electrically controlled upper valve 440, upper tube 442, lower tube 444, electrically controlled lower valve 446, and lower port 448, which subsystem is collectively called herein "the Positive Displacement Pump System". In Figure 11, there is another second electrically operated internal pump, which in this

case is an electrically operated turbine pump 450, which is associated with an upper port 452, electrically operated upper valve 454, upper tube 456, lower tube 458, electrically operated lower valve 460, and lower port 462, which system is collectively called herein "the Secondary Pump System". Figure 11 also shows upper bypass tube 464, electrically operated upper bypass valve 466, connector tube 468, electrically operated lower bypass valve 470, and lower bypass tube 472, which subsystem is collectively called herein "the Bypass System". The 7 conductors (plus armor) from the cablehead are connected to upper electrical plug 473 in the Smart Shuttle. The 7 conductors then proceed through the upper portion of the Smart Shuttle that are figuratively shown as numeral 474 and those electrically insulated wires are connected to Smart Shuttle electronics system module 476. The wire bundle pass through typically having 7 conductors that provide signals and power from the wireline and the Smart Shuttle to the Retrieval Sub are figuratively shown as element 478 and these in turn are connected to lower electrical connector 479. Signals and power from lower electrical connector 479 within the Smart Shuttle are provided as necessary to mating top electrical connector 431 of the Retrieval Sub and then those signals and power are in turn passed through the Retrieval Sub to the retrieval sub electrical connector 313 as shown in Figure 9. Smart Shuttle electronics system module 476 carries out all the other possible functions listed as items (a) to (z), and (aa) to (ab), in the above defined list of "List of Smart Shuttle Features", and those functions include all necessary electronics, computers, processors, measurement devices, etc. to carry out the functions of the Smart Shuttle. Various outputs from the Smart Shuttle electronics system module 476 are figuratively shown as elements 480 to 498. As an example, element 480 provides electrical energy to pump 436;

element 482 provides electrical energy to pump 450; element 484 provides electrical energy to valve 440; element 486 provides electrical energy to valve 446; element 488 provides electrical energy to valve 454; element 490 provides electrical energy to valve 460; element 492 provides electrical energy to valve 466; element 494 provides electrical energy to valve 470; etc. In the end, there may be a hundred or more additional electrical connections to and from the Smart Shuttle electronics system module 476 that are collectively represented by numerals 496 and 498. In Figure 11, the right-hand and left-hand portions of upper Smart Shuttle seal are labeled respectively 500 and 502. Further, the right-hand and left-hand portions of lower Smart Shuttle seal are labeled respectively with numerals 504 and 506. Not shown in Figure 11 are apparatus that may be used to retract these seals under electronic control that would protect the seals from wear during long trips into the hole within mostly vertical well sections where the weight of the smart shuttle means (also "Smart Shuttle means") is sufficient to deploy it into the well under its own weight. These seals would also be suitably retracted when the smart shuttle means is pulled up by the wireline.

The preferred embodiment of the block diagram for a Smart Shuttle has a particular virtue. Electrically operated pump 450 is an electrically operated turbine pump, and when it is operating with valves 454 and 460 open, and the rest closed, it can drag significant loads downhole at relatively high speeds. However, when the well goes horizontal, the loads increase. If electrically operated pump 450 stalls or cavitates, etc., then electrically operated pump 436 that is a positive displacement pump takes over, and in this case, valves 440 and 446 are open, with the rest closed. Pump 436 is a particular type of positive displacement pump that may

be attached to a pump transmission device so that the load presented to the positive displacement pump does not exceed some maximum specification independent of the external load. See Figure 12 for additional details.

The Smart Shuttle shown as element 306 in Figure 10 is an example of "a conveyance means".

Figure 12 shows a block diagram of a pump transmission device 508 that provides a mechanical drive 510 to positive displacement pump 512. Electrical power from the wireline is provided by wire bundle 514 to electric motor 516 and that motor provides a mechanical coupling 518 to pump transmission device 508. Pump transmission device 508 may be an "automatic pump transmission device" in analogy to the operation of an automatic transmission in a vehicle, or pump transmission device 508 may be a "standard pump transmission device" that has discrete mechanical gear ratios that are under control from the surface of the earth. Such a pump transmission device prevents pump stalling, and other pump problems, by matching the load seen by the pump to the power available by the motor. Otherwise, the remaining block diagram for the system would resemble that shown in Figure 11, but that is not shown here for the purposes of brevity.

Another preferred embodiment of the Smart Shuttle contemplates using a "hybrid pump/wheel device". In this approach, a particular hydraulic pump in the Smart Shuttle can be alternatively used to cause a traction wheel to engage the interior of the pipe. In this hybrid approach, a particular hydraulic pump in the Smart Shuttle is used in a first manner as is described in Figures 8 - 12. In this hybrid approach, and by using a set of electrically

controlled valves, a particular hydraulic pump in the Smart Shuttle is used in a second manner to cause a traction wheel to rotate and to engage the pipe that in turn causes the Smart Shuttle to translate within the pipe. There are many designs possible using this "hybrid approach".

Figure 13 shows a block diagram of a preferred embodiment of the Smart Shuttle having a hybrid pump design that is generally designated with the numeral 520. Selected elements ranging from element 436 to element 506 in Figure 13 have otherwise been defined in relation to Figure 11. In addition, inlet port 522 is connected to electrically controlled valve 524 that is in turn connected to two-state valve 526 that may be commanded from the surface of the earth to selectively switch between two states as follows:
"state 1" - the inlet port 522 is connected to secondary pump tube 528 and the traction wheel tube 530 is closed; or
"state 2" - the inlet port 522 is closed, and the secondary pump tube 528 is connected to the traction wheel tube 530. Secondary pump tube 528 in turn is connected to second electrically operated pump 532, tube 534, electrically operated valve 536 and port 538 and operates analogously to elements 452-462 in Figure 11 provided the two-state valve 526 is in state 1.

In Figure 13, in "state 2", with valve 536 open, and when energized, electrically operated pump 532 forces well fluids through tube 528 and through two-state valve 526 and out tube 530. If valve 540 is open, then the fluids continue through tube 542 and to turbine assembly 544 that causes the traction wheel 546 to move the Smart Shuttle downward in the well. In Figure 13, the "turbine bypass tube" for fluids to be sent to the top of the Smart Shuttle AFTER passage through turbine assembly 544 is NOT shown in detail for the purposes

of simplicity only in Figure 13, but this "turbine bypass tube" is figuratively shown by dashed lines as element 548.

In Figure 13, the actuating apparatus causing the traction wheel 546 to engage the pipe on command from the surface is shown figuratively as element 550 in Figure 13. The point is that in "state 2", fluids forced through the turbine assembly 544 cause the traction wheel 546 to make the Smart Shuttle go downward in the well, and during this process, fluids forced through the turbine assembly 544 are "vented" to the "up" side of the Smart Shuttle through "turbine bypass tube" 548. Backing rollers 552 and 554 are figuratively shown in Figure 13, and these rollers take side thrust against the pipe when the traction wheel 546 engages the inside of the pipe.

In the event that seals 500-502 or 504-506 in Figure 13 were to lose hydraulic sealing with the pipe, then "state 2" provides yet another means to cause the Smart Shuttle to go downward in the well under control from the surface. The wireline can provide arbitrary pull in the vertical direction, so in this preferred embodiment, "state 2" is primarily directed at making the Smart Shuttle go downward in the well under command from the surface. Therefore, in Figure 13, there are a total of three independent ways to make the Smart Shuttle go downward under command from the surface of the earth ("standard" use of pump 436; "standard" use of pump 532 in "state 1"; and the use of the traction wheel in "state 2").

The "hybrid pump/wheel device" that is an embodiment of the Smart Shuttle shown in Figure 13 is yet another example of "a conveyance means".

The downward velocity of the Smart Shuttle can be easily determined assuming that electrically operated pump 402 in Figures 9 and 10 are positive displacement pumps so that there is no "pump slippage" caused by pump stalling, cavitation effects, or other pump "imperfections". The following also applies to any pump that pumps a given volume per unit time without any such non-ideal effects. As stated before, in the time interval Δt, a quantity of fluid $\Delta V1$ is pumped from below the Smart Shuttle to above it. Therefore, if the position of the Smart Shuttle changes downward by ΔZ in the time interval Δt, and with radius a1 defined in Figure 10, it is evident that:

$$\Delta V1/\Delta t = \Delta Z/\Delta t \quad \{ \pi \ (a1)^2 \}$$

Equation 1.

$$\text{Downward Velocity} = \Delta Z/\Delta t$$

$$= \{ \Delta V1/\Delta t \} / \{ \pi \ (a1)^2 \}$$

Equation 2.

Here, the "Downward Velocity" defined in Equation 2 is the average downward velocity of the Smart Shuttle that is averaged over many cycles of the pump. After the Smart Shuttle of the Automated Smart Shuttle System is primed, then the Smart Shuttle and its pump resides in a standing fluid column and the fluids are relatively non-compressible. Further, with the above pump transmission device 508 in Figure 12, or equivalent, the electrically operated pump system will not stall. Therefore, when a given volume of

fluid ΔV is pumped from below the Smart Shuttle to above it, the Shuttle will move downward provided the elastomeric seals like elements 500, 502, 504 and 506 in Figures 9, 11, and 13 do not lose hydraulic seal with the casing. Again there are many designs for such seals, and of course, more than two seals can be used along the length of the Smart Shuttle. If the seals momentarily loose their hydraulic sealing ability, then a "hybrid pump/wheel device" as described in Figure 13 can be used momentarily until the seals again make suitable contact with the interior of the pipe.

The preferred embodiment of the Smart Shuttle having internal pump means to pump fluid from below the Smart Shuttle to above it to cause the shuttle to move in the pipe may also be used to replace relatively slow and relatively inefficient "well tractors" that are now commonly used in the industry.

Closed-Loop Completion System

Figure 14 shows a remaining component of the Automated Smart Shuttle System. It is a portion of a preferred embodiment of an automated system to complete oil and gas wells. It is also a portion of a preferred embodiment of a closed-loop system to complete oil and gas wells. Figure 14 shows the computer control of the wireline drum and of the Smart Shuttle in a preferred embodiment of the invention.

In Figure 14, computer system 556 has typical components in the industry including one or more processors, one or more non-volatile memories, one or more volatile memories, many software programs that can run concurrently or alternatively as the situation requires, etc., and all other features as

necessary to provide computer control of the Automated Shuttle System. In this preferred embodiment, this same computer system 556 also has the capability to acquire data from, send commands to, and otherwise properly operate and control all instruments in the Retrievable Instrumentation Package. Therefore LWD and MWD data is acquired by this same computer system when appropriate. Therefore, in one preferred embodiment, the computer system 556 has all necessary components to interact with the Retrievable Instrumentation Package. In a "closed-loop" operation of the system, information obtained downhole from the Retrievable Instrumentation Package is sent to the computer system that is executing a series of programmed steps, whereby those steps may be changed or altered depending upon the information received from the downhole sensor.

In Figure 14, the computer system 556 has a cable 558 that connects it to display console 560. The display console 560 displays data, program steps, and any information required to operate the Smart Shuttle System. The display console is also connected via cable 562 to alarm and communications system 564 that provides proper notification to crews that servicing is required - particularly if the Smart Shuttle chamber 346 in Figure 8 needs servicing that in turn generally involves changing various devices connected to the Smart Shuttle. Data entry and programming console 566 provides means to enter any required digital or manual data, commands, or software as needed by the computer system, and it is connected to the computer system via cable 568.

In Figure 14, computer system 556 provides commands over cable 570 to the electronics interfacing system 572 that has many functions. One function of the electronics interfacing system is to provide information to and from the

Smart Shuttle through cabling 574 that is connected to the slip-ring 576, as is typically used in the industry. The slip-ring 576 is suitably mounted on the side of the wireline drum 578 in Figure 14. Information provided to slip-ring 576 then proceeds to wireline 580 that generally has 7 electrical conductors enclosed in armor. That wireline 580 proceeds to overhead sheave 582 that is suitably suspended above the Wireline Lubricator System in Figure 8. In particular, the lower portion of the wireline 394 shown in Figure 14 is also shown as the top portion of the wireline 394 that enters the Wireline Lubricator System in Figure 8. That particular portion of the wireline 394 is the same in Figure 14 and in Figure 8, and this equality provides a logical connection between these two figures.

In Figure 14, electronics interfacing system 572 also provides power and electronic control of the wireline drum hydraulic motor and pump assembly 584 as is typically used in the industry today (that replaced earlier chain drive systems). Wireline drum hydraulic motor and pump assembly 584 controls the motion of the wireline drum, and when it winds up in the counter-clockwise direction as observed in Figure 14, the Smart Shuttle goes upwards in the wellbore in Figure 8, and Z decreases. Similarly, when the wireline drum hydraulic motor and pump assembly 584 provides motion in the clockwise direction as observed in Figure 14, then the Smart Shuttle goes down in Figure 8 and Z increases. The wireline drum hydraulic motor and pump assembly 584 is connected to cable connector 588 that is in turn connected to cabling 590 that is in turn connected to electronics interfacing system 572 that is in turn controlled by computer system 556. Electronics interfacing system 572 also provides power and electronic control of any coiled tubing rig designated by element 591 (not shown in Figure 14), including the coiled

tubing drum hydraulic motor and pump assembly of that coiled tubing rig, but such a coiled tubing rig is not shown in Figure 14 for the purposes of simplicity. In addition, electronics interfacing system 572 has output cable 592 that provides commands and control to drilling rig hardware control system 594 that controls various drilling rig functions and apparatus including the rotary drilling table motors, the mud pump motors, the pumps that control cement flow and other slurry materials as required, and all electronically controlled valves, and those functions are controlled through cable bundle 596 which has an arrow on it in Figure 14 to indicate that this cabling goes to these enumerated items.

In relation to Figure 14, a preferred embodiment of a portion of the Automated Smart Shuttle System shown in Figure 8 has electronically controlled valves, so that valves 392, 384, 378, 364, 360, 344, 340, 336, 332, and 316 as seen from top to bottom in Figure 8, and are all electronically controlled in this embodiment, and may be opened or shut remotely from drilling rig hardware control system 594. In addition, electronics interfacing system 572 also has cable output 598 to ancillary surface transducer and communications control system 600 that provides any required surface transducers and/or communications devices required for the instrumentation within the Retrievable Instrumentation Package. In a preferred embodiment, ancillary surface and communications system 600 provides acoustic transmitters and acoustic receivers as may be required to communicate to and from the Retrievable Instrumentation Package. The ancillary surface and communications system 600 is connected to the required transducers, etc. by cabling 602 that has an arrow in Figure 14 designating that this cabling proceeds to those enumerated transducers and other devices as may be required.

With respect to Figure 14, and to the closed-loop system to complete oil and gas wells, standard electronic feedback control systems and designs are used to implement the entire system as described above, including those described in the book entitled "Theory and Problems of Feedback and Control Systems", "Second Edition", "Continuous(Analog) and Discrete(Digital)", by J.J. DiStefano III, A.R. Stubberud, and I.J. Williams, Schaum's Outline Series, McGraw-Hill, Inc., New York, New York, 1990, 512 pages, an entire copy of which is incorporated herein by reference. Therefore, in Figure 14, the computer system 556 has the ability to communicate with, and to control, all of the above enumerated devices and functions that have been described in this paragraph.

To emphasize one major point in Figure 14, computer system 556 has the ability to receive information from one or more downhole sensors for the closed-loop system to complete oil and gas wells. This computer system executes a sequence of programmed steps, but those steps may depend upon information obtained from at least one sensor located within the wellbore.

The entire system represented in Figure 14 provides the automation for the "Automated Smart Shuttle Oil and Gas Completion System", or also abbreviated as the "Automated Smart Shuttle System", or the "Smart Shuttle Oil and Gas Completion System". The system in Figure 14 is the "automatic control means" for the "wireline conveyed shuttle means having retrieval and installation means" (also wireline conveyed Smart Shuttle means having retrieval and installation means"), or simply the "automatic control means" for the "smart shuttle means" (also "Smart Shuttle means").

Steps to Complete Well Shown in Figure 6

The following describes the completion of one well commencing with the well diagram shown in Figure 6. In Figure 6, it is assumed that the well has been drilled to total depth. Furthermore, it is also assumed here that all geophysical information is known about the geological formation because the embodiment of the Retrievable Instrumentation Package shown in Figure 6 has provided complete LWD/MWD information.

The first step is to disconnect the top of the drill pipe 170, or casing as appropriate, in Figure 6 from the drilling rig apparatus. In this step, the kelly, etc. is disconnected and removed from the drill string that is otherwise held in place with slips as necessary until the next step.

In addition to typical well control procedures, the second step is to attach to the top of that drill pipe first blowout preventer 316 and top drill pipe flange 320 as shown in Figure 8, and to otherwise attach to that flange 320 various portions of the Automated Smart Shuttle System shown in Figure 8 including the "Wiper Plug Pump-Down Stack" 322, the "Smart Shuttle Chamber" 346, and the "Wireline Lubricator System" 374, which are subassemblies that are shown in their final positions after assembly in Figure 8.

The third step is the "priming" of the Automated Smart Shuttle System as described in relation to Figure 8.

The fourth step is to retrieve the Retrievable Instrumentation Package. Please recall that the Retrievable Instrumentation Package has heretofore provided all

information about the wellbore, including the depth, geophysical parameters, etc. Therefore, computer system 556 in Figure 14 already has this information in its memory and is available for other programs. "Program A" of the computer system 556 is instigated that automatically sends the Smart Shuttle 306 and its Retrieval Sub 308 (see Figure 9) down into the drill string, and causes the electronically controllable retrieval snap ring assembly 310 in Figure 9 to positively snap into the retrieval grove 298 of element 206 of the Retrievable Instrumentation Package in Figure 7 when the mating nose 312 of the Retrieval Sub in Figure 9 enters mud passage 198 of the Retrievable Instrumentation Package in Figure 7. Thereafter, the Retrieval Sub has "latched onto" the Retrievable Instrumentation Package. Thereafter, a command is given by the computer system that pulls up on the wireline thereby disengaging mating electrical connectors 232 and 234 in Figure 7, and pulling piston 254 through bore 258 in the body of the Smart Drilling and Completion Sub in Figure 7. Thereafter, the Smart Shuttle, the Retrieval Sub, and the Retrievable Instrumentation Package under automatic control of "Program A" return to the surface as one unit. Thereafter, "Program A" causes the Smart Shuttle and the Retrieval Sub to "park" the Retrievable Instrumentation Package within the "Smart Shuttle Chamber" 346 and adjacent to the Smart Shuttle chamber door 348. Thereafter, the alarm and communications system 564 sounds a suitable "alarm" to the crew that servicing is required - in this case the Retrievable Instrumentation Package needs to be retrieved from the Smart Shuttle Chamber. The fourth step is completed when the Retrievable Instrumentation Package is removed from the Smart Shuttle Chamber. As an alternative, an automated "hopper system" under control of the computer system can replace the functions of the servicing crew therefore making this portion of the completion an entirely automated process

or as a part of a closed-loop system to complete oil and gas wells.

The fifth step is to pump down cement and gravel using a suitable pump-down latching one-way valve means and a series of wiper plugs to prepare the bottom portion of the drill string for the final completion steps. The procedure here is followed in analogy with those described in relation to Figures 1-4 above. Here, however, the pump-down latching one-way valve means that is similar to the Latching Float Collar Valve Assembly 20 in Figure 1 is also fitted with apparatus attached to its Upper Seal 22 that provides similar apparatus and function to element 206 of the Retrievable Instrumentation Package in Figure 7. Put simply, a device similar to the Latching Float Collar Valve Assembly 20 in Figure 1 is fitted with additional apparatus so that it may be conveniently deployed in the well by the Retrieval Sub. Wiper plugs are similarly fitted with such apparatus so that they can also be deployed in the well by the Retrieval Sub. As an example of such fitted apparatus, wiper plugs are fabricated that have rubber attachment features so that they can be mated to the Retrieval Sub in the Smart Shuttle Chamber. A cross section of such a rubber-type material wiper plug is generally shown as element 604 in **Figure 15**; which has upper wiper attachment apparatus 606 that provides similar apparatus and function to element 206 of the Retrievable Instrumentation Package in Figure 7; and which has flexible upper wiper blade 608 to fit the interior of the pipe present; flexible lower wiper blade 610 to fit the interior of the pipe present; wiper plug indentation region between the blades specified by numeral 612; wiper plug interior recession region 614; and wiper plug perforation wall 616 that perforates under suitable applied pressure; and where in some forms of the wiper plugs called "solid wiper

plugs", there is no such wiper plug interior recession region and no portion of the plug wall can be perforated; and where the legends of "UP" and "DOWN" are also shown in Figure 15. In part because the wiper plug shown in Figure 15 may be conveyed downhole with the Retrieval Sub, it is an example of a "smart wiper plug". Further, this smart wiper plug may also possess one or more downhole sensors that provides information to the computer system that controls the well completion process. Accordingly, a pump-down latching one-way valve means is attached to the Retrieval Sub in the Smart Shuttle Chamber, and the computer system is operated using "Program B", where the pump-down latching one-way valve means is placed at, and is released in the pipe adjacent to riser hanger apparatus 315 in Figure 8. Then, under "Program B", perforable wiper plug #1 is attached to the Retrieval Sub in the Smart Shuttle Chamber, and it is placed at and released adjacent to region A in Figure 8. Not shown in Figure 8 are optional controllable "wiper holding apparatus" that on suitable commands fit into the wiper plug indentation region 612 and temporally hold the wiper plug in place within the pipe in Figure 8. Then under "Program B", perforable wiper plug #2 is attached to the Retrieval Sub in the Smart Shuttle Chamber, and it is placed at and released adjacent to region B in Figure 8. Then under "Program B", solid wiper plug #3 is attached to the Retrieval Sub in the Smart Shuttle Chamber, and it is placed at and released adjacent to region C in Figure 8, and the Smart Shuttle and the Retrieval Sub are "parked" in region E of the Smart Shuttle Chamber in Figure 8. Then the Smart Shuttle Chamber is closed, and the chamber itself is suitably "primed" with well fluids. Then, with other valves closed, valve 332 is the opened, and "first volume of cement" is pumped into the pipe forcing the pump-down latching one-way valve means to be forced downward. Then valve 332 is closed, and valve 336 is opened, and a

predetermined volume of gravel is forced into the pipe that in turn forces wiper plug #1 and the one-way valve means downward. Then, valve 336 is closed, and valve 338 opened, and a "second volume of cement" is pumped into the pipe forcing wiper plugs #1 and #2 and the one-way valve means downward. Then valve #338 is closed, and valve 344 is opened, and water is injected into the system forcing wiper plugs #1, #2, and #3, and the one-way valve means downward. Then the latching apparatus of the pump-down latching one-way valve means appropriately seats in latch recession 210 of the Smart Drilling and Completion Sub in Figure 8 that was previously used to latch into place the Retrievable Instrumentation Package. From this disclosure, the pump-down latching one-way valve means has latching means resembling element 208 of the Retrievable Instrumentation Package so that it can latch into place in latch recession 210 of the Smart Drilling and Completion Sub. In the end, the sequential charges of cement, gravel, and then cement are forced through the respective perforated wiper plugs and the one-way valve means and through the mud passages in the drill bit and into the annulus between the drill pipe and the wellbore. Valve 344 is then closed, and pressure is then released in the drill pipe, and the one-way valve means allows the first and second volumes of cement to set up properly on the outside of the drill pipe. After "Program B" is completed, the communications system 564 sounds a suitable "alarm" that the next step should be taken to complete the well. As previously described, an automated "hopper system" under control of the computer system can load the requirement devices into the Smart Shuttle Chamber, and can also suitably control all valves, pumps, etc. so as to make this a completed automated procedure, or as part of a closed-loop system to complete oil and gas wells.

The sixth step is to saw slots in the drill pipe similar to the slot that is labeled with numeral 178 in Figure 5. Accordingly, a "Casing Saw" is fitted so that it can be attached to and deployed by the Retrieval Sub. This Casing Saw is figuratively shown in **Figure 16** as element 618. The Casing Saw 618 has upper attachment apparatus 620 that provides similar apparatus and mechanical functions as provided by element 206 of the Retrievable Instrumentation Package in Figure 7 - but, that in addition, it also has top electrical connector 622 that mates to the retrieval sub electrical connector 313 shown in Figure 9. These mating electrical connectors 313 and 622 provide electrical energy from the wireline, and command and control signals, to and from the Smart Shuttle as necessary to properly operate the Casing Saw. First casing saw blade 624 is attached to first casing saw arm 626. Second casing saw blade 628 is attached to second casing saw arm 630. Casing saw module 632 provides actuating means to deploy the arms, control signals, and the electrical and any hydraulic systems to rotate the casing saw blades. The casing saw may have one or more downhole sensors to provide measured information to the computer system on the surface. Further, this casing saw may also possess one or more downhole sensors that provides information to the computer system that controls the well completion process. Figure 16 shows the saw blades in their extended "out position", but during any trip downhole, the blades would be in the retracted or "in position". In part because the Casing Saw in Figure 15 may be conveyed downhole with the Retrieval Sub, it is an example of a "Smart Casing Saw". Therefore, during this sixth step, the Casing Saw is suitably attached to the Retrieval Sub, the Smart Shuttle Chamber 346 is suitably primed, and then the computer system 556 is operated using "Program C" that automatically controls the wireline drum and the Smart Shuttle so that the Casing Saw is

properly deployed at the correct depth, the casing saw arms and saw blades are properly deployed, and the Casing Saw properly cuts slots through the casing. The "internal pump of the Smart Shuttle" 402 may be used in principle to make the Smart Shuttle go up or down in the well, and in this case, as the saw cuts slots through the casing, it moves up slowly under its own power - and under suitable tension applied to the wireline that is recommended to prevent a disastrous "overrun" of the wireline. After the slots are cut in the casing, the Casing Saw is then returned to the surface of the earth under "Program C" and thereafter, the communications system 564 sounds a suitable "alarm", indicating that crew servicing is required - and in this case, the Casing Saw needs to be retrieved from the Smart Shuttle Chamber. As an alternative, the previously described automated "hopper system" under control of the computer system can replace the functions of the servicing crew therefore making this portion of the completion an entirely automated process, or as part of a closed-loop system to complete oil and gas wells. For a simple single-zone completion system, a coiled tubing conveyed packer can be used to complete the well. For a simple single-zone completion system, only several more steps are necessary. Basically, the wireline system is removed and a coiled tubing rig is used to complete the well.

The seventh step is to close the first blowout preventer 316 in Figure 8. This will prevent any well pressure from causing problems in the following procedure. Then, remove the Smart Shuttle and the Retrieval Sub from the cablehead 304, and remove these devices from the Smart Shuttle Chamber. Then, remove the bolts in flanges 376 and 368, and then remove the entire Wireline Lubricator System 374 in Figure 8. Then replace the Wireline Lubricator System with a Coiled

Tubing Lubricator System that looks similar to element 374 in Figure 8, except that the wireline in Figure 8 is replaced with a coiled tubing. At this point, the Coiled Tubing Lubricator System is bolted in place to flange 368 in Figure 8. **Figure 17** shows the Coiled Tubing Lubricator System 634. The bottom flange of the Coiled Tubing Lubricator System 636 is designed to mate to upper Smart Shuttle chamber flange 368. These two flanges join at the position marked by numeral 638. The Coiled Tubing Lubricator System in Figure 17 has various additional features, including a second blowout preventer 640, coiled tubing lubricator top body 642, fluid control pipe 644 and its fluid control valve 646, a hydraulic packing gland generally designated by numeral 648 in Figure 17, having gland sealing apparatus 650, grease packing pipe 652 and grease packing valve 654. In the industry, the hydraulic packing gland generally designated by numeral 648 in Figure 17 is often called the "stripper" which has at least the following functions: (a) it forms a dynamic seal around the coiled tubing when the tubing goes into the wellbore or comes out of the wellbore; and (b) it provides some means to change gland sealing apparatus or "packing elements" without removing the coiled tubing from the well. Coiled tubing 656 feeds through the Coiled Tubing Lubricator System and the bottom of the coiled tubing is at the position Y measured from the position marked by numeral 638 in Figure 17. Attached to the coiled tubing a distance d1 above the bottom of the end of the coil tubing is the pump-down single zone packer apparatus 658. In several preferred embodiments of the invention, one or more downhole sensors, related electronics, related batteries or other power source, and one or more communication systems within the pump-down single zone packer apparatus provide information to a computer system controlling the well completion process. The entire system in Figure 17 is then

primed with fluids such as water using techniques already explained. Then, and with the other appropriate valves closed in Figure 17, primary injector tube valve 344 is then opened, and water or other fluids are injected into primary injector tube 342. Then the pressure on top surface of the pump-down single zone packer apparatus forces the packer apparatus downward, thereby increasing the distance Y, but when it does so, fluid ΔV2 is displaced, and it goes up the interior of the coiled tubing and to coiled tubing pressure relief valve 660 near the coiled tubing rig (not shown in Figure 17) and the fluid volume ΔV2 is emptied into a holding tank 662 (not shown in Figure 17). Alternatively, instead of emptying the fluid into the holding tank, the fluid can be suitably recirculated with a suitably connected recirculating pump, although that recirculating pump is not shown in Figure 17 for brevity - and such recirculating pump would also minimize the size of the holding tank which is an important feature particularly for offshore use. Still further, the pressure relief valve in the coiled tubing rig is not shown herein, nor is the holding tank, nor is the coiled tubing rig - solely for the purposes of brevity. This hydraulic method of forcing, or "pulling", the tubing into the wellbore will force it down into vertical sections of the wellbore. In such vertical sections of the wellbore, the weight of tubing also assists downward motion within the wellbore. However, of particular interest, this embodiment of the invention also works exceptionally well to force, or "pull", the coiled tubing into horizontal or other highly deviated portions of the wellbore. This is a significant improvement over other methods and apparatus typically used in the industry. This embodiment of the invention can also be used in combination with standard mechanical "injectors" used in the industry. Those mechanical "injectors" provide an axial force on the coiled tubing forcing it into, or out of the well, and there

are many commercial manufactures of such devices. For example, please refer to the volume entitled "Coiled Tubing and Its Applications", having the author of Mr. Scott Quigley, presented during a "Short Course" at the "1999 SPE Annual Technical Conference and Exhibition", October 3-6, Houston, Texas, copyrighted by the Society of Petroleum Engineers, which society is located in Richardson, Texas, an entire copy of which volume is incorporated herein by reference. With reference to Figure 17, the mechanical "injector" 663 (not shown in Figure 17), the guide arch, the reel, the power pack, and the control cabin normally associated with an entire "coiled tubing rig" is not shown in Figure 17 solely for the purpose of brevity. If a mechanical "injector" is used to assist forcing the pump-down single zone packer apparatus 658 into the wellbore, then it is prudent to make sure that there is sufficient hydraulic force applied to the packer apparatus 658 so that the tubing along its entire length is under suitable tension so that it will not "overrun" or "override" the packer apparatus 658. So, even if the mechanical "injector" is assisting the entry of the coiled tubing, the tubing should still be "pulled down into the wellbore" by hydraulic pressure applied to the pump-down single zone packer apparatus 658. **Figure 17A** shows additional detail in the pump-down single zone packer apparatus 658 which possesses a wiper-plug type elastomeric main body having lobes 659 that slide along the interior of the pipe, and in addition, a portion of the elastomeric unit is permanently attached to the tubing in the region designated as 661 in Figure 17A. The lobes 659 in the elastomeric unit are similar to the "Top Wiper Plug Lobe" 70 in Figure 1. Hydraulic force applied to the elastomeric unit causes the tubing to be "pulled" into the pipe disposed in the wellbore, or "forced" into the pipe disposed in the wellbore, and therefore that elastomeric unit acts like a

form of a "tractor" to pull that tubing into the pipe that is disposed in wellbore. The pump-down single zone packer apparatus 658 in Figures 17 and 17A are very simple embodiments of the a "tubing conveyed smart shuttles means" (also "tubing conveyed Smart Shuttle means"). In general, a "tubing conveyed smart shuttle means" also has "retrieval and installation means" for attachment of suitable "smart completion means" for yet additional embodiments of the invention that are not shown herein for brevity. For additional references on coiled tubing rigs, and related apparatus and methods, the interested reader is referred to the book entitled "World Oil's Coiled Tubing Handbook", M.E. Teel, Engineering Editor, Gulf Publishing Company, Houston, Texas, 1993, 126 pages, an entire copy of which is incorporated herein by reference. The coiled tubing rig is controlled with the computer system 556 in Figure 14 and through the electronics interfacing system 572 and therefore the coiled tubing rig and the coiled tubing is under computer control. Then, using techniques already described, the computer system 556 runs "Program D" that deploys the pump-down single zone packer apparatus 658 at the appropriate depth from the surface of the earth. In the end, this well is completed in a configuration resembling a "Single-Zone Completion" as shown in detail in Figure 18 on page 21 of the reference entitled "Well Completion Methods", Lesson 4, "Lessons in Well Servicing and Workover", published by the Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1971, total of 49 pages, an entire copy of which is incorporated herein by reference, and that was previously defined as "Ref. 2". It should be noted that the coiled tubing described here can also have a wireline disposed within the coiled tubing using typical techniques in the industry. From this disclosure in the seventh step, it should also be stated here that any of the above defined

smart completion devices could also be installed into the wellbore with a tubing conveyed smart shuttle means or a tubing with wireline conveyed smart shuttle means - should any other smart completion devices be necessary before the completion of the above step. It should be noted that all aspects of this seventh step including the control of the coiled tubing rig, actuators for valves, any automated hopper functions, etc., can be completely automated under the control of the computer system making this portion of the well completion an entirely automated process or as part of a closed-loop system to complete oil and gas wells.

The eighth step includes suitably closing first blowout preventer 316 or other valve as necessary, and removing in sequence the Coiled Tubing Lubricator System 634, the Smart Shuttle Chamber System 372, and the Wiper Plug Pump-Down Stack 322, and then using usual techniques in the industry, adding suitable wellhead equipment, and commencing oil and gas production. Such wellhead equipment is shown in Figure 39 on page 37 of the book entitled "Testing and Completing", Second Edition, Unit II, Lesson 5, published by the Petroleum Extension Service of the University of Texas, Austin, Texas, 1983, 56 pages total, an entire copy of which is incorporated herein by reference, that was previously defined as "Ref. 4" above.

List of Smart Completion Devices

In light of the above disclosure, it should be evident that there are many uses for the Smart Shuttle and its Retrieval Sub. One use was to retrieve from the drill string the Retrievable Instrumentation Package. Another was to deploy into the well suitable pump-down latching one-way

valve means and a series of wiper plugs. And yet another was to deploy into the well and retrieve the Casing Saw.

The deployment into the wellbore of the well suitable pump-down latching one-way valve means and a series of wiper plugs and the Casing Saw are examples of "Smart Completion Devices" being deployed into the well with the Smart Shuttle and its Retrieval Sub. Put another way, a "Smart Completion Device" is any device capable of being deployed into the well and retrieved from the well with the Smart Shuttle and its Retrieval Sub and such a device may also be called a "smart completion means". These "Smart Completion Devices" may often have upper attachment apparatus similar to that shown in elements 620 and 622 in Figure 16.

Any "Smart Completion Device" may have installed within it one or more suitable sensors, measurement apparatus associated with those sensors, batteries and/or power source, and communication means for transmitting the measured information to the Smart Shuttle, and/or to a Retrieval Sub, and/or to the surface. Any "Smart Completion Device" may also have installed within it suitable means to receive commands from the Smart Shuttle and or from the surface of the earth.

The following is a brief initial list of Smart Completion Devices that may be deployed into the well by the Smart Shuttle and its Retrieval Sub:

(1) smart pump-down one-way cement valves of all types

(2) smart pump-down one-way cement valve with controlled casing locking mechanism

(3) smart pump-down latching one-way cement valve

(4) smart wiper plug

(5) smart wiper plug with controlled casing locking mechanism

(6) smart latching wiper plug

(7) smart wiper plug system for One-Trip-Down-Drilling

(8) smart pump-down wiper plug for cement squeeze jobs with controlled casing locking mechanism

(9) smart pump-down plug system for cement squeeze jobs

(10) smart pump-down wireline latching retriever

(11) smart receiver for smart pump-down wireline latching retriever

(12) smart receivable latching electronics package providing any type of MWD, LWD, and drill bit monitoring information

(13) smart pump-down and retrievable latching electronics package providing MWD, LWD, and drill bit monitoring information

(14) smart pump-down whipstock with controlled casing locking mechanism

(15) smart drill bit vibration damper

(16) smart drill collar

(17) smart pump-down robotic pig to machine slots in drill pipes and casing to complete oil and gas wells

(18) smart pump-down robotic pig to chemically treat inside of drill pipes and casings to complete oil and gas wells

(19) smart milling pig to fabricate or mill any required slots, holes, or other patterns in drill pipes to complete oil and gas wells

(20) smart liner hanger apparatus

(21) smart liner installation apparatus

(22) smart packer for One-Trip-Down-Drilling

(23) smart packer system for One-Trip-Down-Drilling

(24) smart drill stem tester

From the above list, the "smart completion means" includes smart one-way valve means; smart one-way valve means with controlled casing locking means; smart one-way valve means with latching means; smart wiper plug means; smart wiper plug means with controlled casing locking means; smart wiper plugs with latching means; smart wiper plug means for cement squeeze jobs having controlled casing locking means; smart retrievable latching electronics means; smart whipstock means with controlled casing locking means; smart drill bit vibration damping means; smart robotic pig means to machine slots in pipes; smart robotic pig means to chemically treat inside of pipes; smart robotic pig means to mill any required slots or other patterns in pipes; smart liner installation means; and smart packer means.

In the above, the term "pump-down" may mean one or both of the following depending on the context: (a) "pump-down" can mean that the "internal pump of the Smart Shuttle" 402 is used to translate the Smart Shuttle downward into the well; or (b) force on fluids introduced by inlets into the Smart Shuttle Chamber and other inlets can be used to force down wiper-plug like devices as described above. The term "casing locking mechanism" has been used above that means, in this case, it locks into the interior of the drill pipe, casing, or whatever pipe in which it is installed. Many of the preferred embodiments herein can also be used in standard casing installations which is a subject that will be described below.

In summary, a "wireline conveyed smart shuttle means" has "retrieval and installation means" for attachment of suitable "smart completion means". A "tubing conveyed smart shuttle means" also has "retrieval and installation means" for attachment of suitable "smart completion means". If a

wireline is inside the tubing, then a "tubing with wireline conveyed shuttle means" (also "tubing with wireline conveyed Smart Shuttle means") has "retrieval and installation means" for attachment of "smart completion means". As described in this paragraph, and depending on the context, a "smart shuttle means" may refer to a "wireline conveyed smart shuttle means" or to a "tubing conveyed smart shuttle means", whichever may be appropriate from the particular usage. It should also be stated that a "smart shuttle means" may be deployed into a well substantially under the control of a computer system which is an example of a "closed-loop completion system".

Put yet another way, the smart shuttle means may be deployed into a pipe with a wireline means, with a tubing means, with a tubing conveyed wireline means, and as a robotic means, meaning that the Smart Shuttle provides its own power and is untethered from any wireline or tubing, and in such a case, it is called "an untethered robotic smart shuttle means" (also "an untethered robotic Smart Shuttle means") for the purposes herein.

It should also be stated for completeness here that any means that are installed in wellbores to complete oil and gas wells that are described in Ref. 1, in Ref. 2, and Ref. 4 (defined above, and mentioned again below), and which can be suitably attached to the retrieval and installation means of a smart shuttle means shall be defined herein as yet another smart completion means. For example, in another embodiment, a retrieval sub may be suitably attached to a wireline-conveyed well tractor, and the wireline-conveyed well tractor may be used to convey downhole various smart completion devices attached to the retrieval sub for deployment within the wellbore to complete oil and gas wells.

More Complex Completions of Oil and Gas Wells

Various different well completions typically used in the industry are described in the following references:

(a) "Casing and Cementing", Unit II, Lesson 4, Second Edition, of the Rotary Drilling Series, Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1982 (defined earlier as "Ref. 1" above)

(b) "Well Completion Methods", Lesson 4, from the series entitled "Lessons in Well Servicing and Workover", Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1971 (defined earlier as "Ref. 2" above)

(c) "Testing and Completing", Unit II, Lesson 5, Second Edition, of the Rotary Drilling Series, Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1983 (defined earlier as "Ref. 4")

(d) "Well Cleanout and Repair Methods", Lesson 8, from the series entitled "Lessons in Well Servicing and Workover", Petroleum Extension Service, The University of Texas at Austin, Austin, Texas, 1971

It is evident from the preferred embodiments above, and the description of more complex well completions in (a), (b), (c), and (d) herein, that Smart Shuttles with Retrieval Subs deploying and retrieving various different Smart Completion Devices can be used to complete a vast majority of oil and gas wells. Here, the Smart Shuttles may be either wireline conveyed, or tubing conveyed, whichever is most convenient. Single string dual completion wells may be completed in

analogy with Figure 21 in "Ref. 4". Single-string dual completion wells may be completed in analogy with Figure 22 in "Ref. 4". A smart pig to fabricate holes or other patterns in drill pipes (item 19 above) can be used in conjunction with the a smart pump-down whipstock with controlled casing locking mechanism (item 14 above) to allow kick-off wells to be drilled and completed.

It is further evident from the preferred embodiments above that Smart Shuttles with Retrieval Subs deploying and retrieving various different Smart Completion Devices can be also used to complete multilateral wellbores. Here, the Smart Shuttles may be either wireline conveyed, or tubing conveyed, whichever is most convenient. For a description of such multilateral wells, please refer to the volume entitled "Multilateral Well Technology", having the author of "Baker Hughes, Inc.", that was presented in part by Mr. Randall Cade of Baker Oil Tools, that was handed-out during a "Short Course" at the "1999 SPE Annual Technical Conference and Exhibition", October 3-6, Houston, Texas, having the symbol of "SPE International Education Services" on the front page of the volume, a symbol of the Society of Petroleum Engineers, which society is located in Richardson, Texas, an entire copy of which volume is incorporated herein by reference.

During more complex completion processes of wellbores, it may be useful to alternate between wireline conveyed smart shuttle means and coiled tubing conveyed smart shuttle means. Of course, the "Wireline Lubricator System" 374 in Figure 8 and the Coiled Tubing Lubricator System 634 in Figure 17 can be alternatively mated in sequence to the upper Smart Shuttle chamber flange 368 shown in Figures 8 and 17. However, if many such sequential operations, or "switches",

are necessary, then there is a more efficient alternative. One embodiment of this more efficient alternative is to suitably mount on top of the upper Smart Shuttle chamber flange 368, and at the same time, both a Wireline Lubricator System and a Coiled Tubing Lubricator System. There are many ways to design and build such a system that allows for needed space for simultaneously disposing wireline conveyed smart shuttle means and coiled tubing conveyed smart shuttle means within the Smart Shuttle Chamber 346, which chamber is generally shown in Figures 8 and 17, and in other pertinent portion of the system. Yet another embodiment comprises at least one "motion means" and at least one "sealing means" so that the Wireline Lubricator System and the Coiled Tubing Lubricator System can be suitably moved back and forth with respect to the upper Smart Shuttle chamber flange 368, so that the unit that is required during any one step is centered directly over whatever pipe is disposed in wellbore. There are many possibilities. For the purposes herein, a "Dual Lubricator Smart Shuttle System" is one that is suitably fitted with both a Wireline Lubricator System and a Coiled Tubing Lubricator System so that either wireline or tubing conveyed Smart Shuttles can be efficiently used in any order to efficiently complete the oil and gas well. Such a "Dual Lubricator Smart Shuttle System" would be particularly useful in very complex well completions, such as in some multilateral well completions, because it may be necessary to change the order of the completion sequence if unforseen events transpire. No drawing is provided herein of the "Dual Lubricator Smart Shuttle System" for brevity, but one could easily be generated by suitable combination of the relevant elements in Figures 8 and 17 and at least one "motion means" and at least one "sealing means". Further, any "Dual Lubricator Smart Shuttle System" that is substantially under the control of a computer system that also receives suitable

downhole information is another example of a closed-loop completion system to complete oil and gas wells.

Smart Shuttles and Standard Casing Strings

Many preferred embodiments of the invention above have referred to drilling and completing through the drill string. However, it is now evident from the above embodiments and the descriptions thereof, that many of the above inventions can be equally useful to complete oil and gas wells with standard well casing. For a description of procedures involving standard casing operations, see Steps 9, 10, 11, 12, 13, and 14 of the specification under the subtitle entitled "Typical Drilling Process".

Therefore, any embodiment of the invention that pertains to a pipe that is a drill string, also pertains to pipe that is a casing. Put another way, many of the above embodiments of the invention will function in any pipe of any material, any metallic pipe, any steel pipe, any drill pipe, any drill string, any casing, any casing string, any suitably sized liner, any suitably sized tubing, or within any means to convey oil and gas to the surface for production, hereinafter defined as "pipe means".

Figure 18 shows such a "pipe means" disposed in the open hole 184 that is also called the wellbore here. All the numerals through numeral 184 have been previously defined in relation to Figure 6. A "pipe means" 664 is deployed in the wellbore that may be a pipe made of any material, a metallic pipe, a steel pipe, a drill pipe, a drill string, a casing, a casing string, a liner, a liner string, tubing, or a tubing string, or any means to convey oil and gas to the surface for

production. The "pipe means" may, or may not have threaded joints in the event that the "pipe means" is tubing, but if those threaded joints are present, they are labeled with the numeral 666 in Figure 18. The end of the wellbore 668 is shown. There is no drill bit attached to the last section 670 of the "pipe means". In Figure 18, if the "pipe means" is a drill pipe, or drill string, then the retractable bit has been removed one way or another as explained in the next section entitled "Smart Shuttles and Retrievable Drill Bits". If the "pipe means" is a casing, or casing string, then the last section of casing present might also have attached to it a casing shoe as explained earlier, but that device is not shown in Figure 18 for simplicity.

From the disclosure herein, it should now be evident that the above defined "smart shuttle means" having "retrieval and installation means" can be used to install within the "pipe means" any of the above defined "smart completion means". Here, the "smart shuttle means" includes a "wireline conveyed shuttle means" and/or a "tubing conveyed shuttle means" and/or a "tubing with wireline conveyed shuttle means".

Retrievable Drill Bits and Installation of One-Way Valves

A first definition of the phrases "one pass drilling", "One-Trip-Drilling" and "One-Trip-Down-Drilling" is quoted above to "mean the process that results in the last long piece of pipe put in the wellbore to which a drill bit is attached is left in place after total depth is reached, and is completed in place, and oil and gas is ultimately produced from within the wellbore through that long piece of pipe. Of course, other pipes, including risers, conductor pipes,

surface casings, intermediate casings, etc., may be present, but the last very long pipe attached to the drill bit that reaches the final depth is left in place and the well is completed using this first definition. This process is directed at dramatically reducing the number of steps to drill and complete oil and gas wells."

This concept, however, can be generalized one step further that is another embodiment of the invention. As many prior patents show, it is possible to drill a well with a "retrievable drill bit" that is otherwise also called a "retractable drill bit". For the purposes of this invention, a retrievable drill bit may be equivalent to a retractable drill bit in one embodiment. For example, see the following U.S. Patents: U.S. Patent No. 3,552,508, C.C. Brown, entitled "Apparatus for Rotary Drilling of Wells Using Casing as the Drill Pipe", that issued on 1/5/1971, an entire copy of which is incorporated herein by reference; U.S. Patent No. 3,603,411, H.D. Link, entitled "Retractable Drill Bits", that issued on 9/7/1971, an entire copy of which is incorporated herein by reference; U.S. Patent No. 4,651,837, W.G. Mayfield, entitled "Downhole Retrievable Drill Bit", that issued on 3/24/1987, an entire copy of which is incorporated herein by reference; U.S. Patent No. 4,962,822, J.H. Pascale, entitled "Downhole Drill Bit and Bit Coupling", that issued on 10/16/1990, an entire copy of which is incorporated herein by reference; and U.S. Patent No. 5,197,553, R.E. Leturno, entitled "Drilling with Casing and Retrievable Drill Bit", that issued on 3/30/1993, an entire copy of which is incorporated herein by reference. Some experts in the industry call this type of drilling technology to be "drilling with casing". For the purposes herein, the terms "retrievable drill bit", "retrievable drill

bit means", "retractable drill bit" and "retractable drill bit means" may be used interchangeably.

For the purposes of logical explanation at this point, in the event that any drill pipe is used to drill any extended reach lateral wellbore from any offshore platform, and in addition that wellbore perhaps reaches 20 miles laterally from the offshore platform, then to save time and money, the assembled pipe itself should be left in place and not tripped back to the platform. This is true whether or not the drill bit is left on the end of the pipe, or whether or not the well was drilled with so-called "casing drilling" methods. For typical casing-while-drilling methods, see the article entitled "Casing-while-drilling: The next step change in well construction", World Oil, October, 1999, pages 34-40, and entire copy of which is incorporated herein by reference. Further, all terms and definitions in this particular article, and entire copies of each and every one of the 13 references cited at the end this article are incorporated herein by reference.

Accordingly a more general second definition of the phrases "one pass drilling", "One-Trip-Drilling" and "One-Trip-Down-Drilling" shall include the concept that once the drill pipe means reaches total depth and any maximum extended lateral reach, that the pipe means is thereafter left in place and the well is completed. The above embodiments have adequately discussed the cases of leaving the drill bit attached to the drill pipe and completing the oil and gas wells. In the case of a retrievable bit, the bit itself can be left in place and the well completed without retrieving the bit, but the above apparatus and methods of operation using the Smart Shuttle, the Retrieval Sub, and the various Smart Production Devices can also be used in the

drill pipe means that is left in place following the removal of a retrievable bit. This also includes leaving ordinary casing in place following the removal of a retrieval bit and any underreamer during casing drilling operations. This process also includes leaving any type of pipe, tubing, casing, etc. in the wellbore following the removal of the retrievable bit.

In particular, following the removal of a retrievable drill bit during wellboring activities, one of the first steps to complete the well is to prepare the bottom of the well for production using one-way valves, wiper plugs, cement, and gravel as described in relation to Figures 4, 5, and 8 and as further described in the "fifth step" above under the subtopic of "Steps to Complete Well Shown in Figure 6". The use of one-way valves installed within a drill pipe means following the removal of a retrievable drill bit that allows proper cementation of the wellbore is another embodiment of the invention. These one-way valves can be installed with the Smart Shuttle and its Retrieval Sub, or they can be simply pumped-down from the surface using techniques shown in Figure 1 and in the previously described "fifth step".

In accordance with the above, a preferred embodiment of the invention is a method of one pass drilling from an offshore platform of a geological formation of interest to produce hydrocarbons comprising at least the following steps: (a) attaching a retrievable drill bit to a casing string located on an offshore platform; (b) drilling a borehole into the earth from the offshore platform to a geological formation of interest; (c) retrieving the retrievable drill bit from the casing string; (d) providing a pathway for fluids to enter into the casing from the geological formation

of interest; (e) completing the well adjacent to the formation of interest with at least one of cement, gravel, chemical ingredients, mud; and (f) passing the hydrocarbons through the casing to the surface of the earth. Such a method applies wherein the borehole is an extended reach wellbore and wherein the borehole is an extended reach lateral wellbore.

In accordance with the above, a preferred embodiment of the invention is a method of one pass drilling from an offshore platform of a geological formation of interest to produce hydrocarbons comprising at least the following steps: (a) attaching a retractable drill bit to a casing string located on an offshore platform; (b) drilling a borehole into the earth from the offshore platform to a geological formation of interest; (c) retrieving the retractable drill bit from the casing string; (d) providing a pathway for fluids to enter into the casing from the geological formation of interest; (e) completing the well adjacent to the formation of interest with at least one of cement, gravel, chemical ingredients, mud; and (f) passing the hydrocarbons through the casing to the surface of the earth. Such a method applies wherein the borehole is an extended reach wellbore and wherein the borehole is an extended reach lateral wellbore.

Figure 18A shows a modified form of Figure 18 wherein the last portion of the "pipe means" 672 has "pipe mounted latching means" 674. This "pipe mounted latching means" may be used for a number of purposes including at least the following: (a) an attachment means for attaching a retrievable drill bit to the last section of the "pipe means"; and (b) a "stop" for a pump-down one-way valve means following the retrieval of the retrievable drill bit. In

some contexts this "pipe mounted latching means" 674 is also called a "landing means" for brevity. Therefore, an embodiment of this invention is methods and apparatus to install one-way cement valve means in drill pipe means following the removal of a retrievable drill bit to produce oil and gas. It should also be stated that well completion processes that include the removal of a retrievable drill bit may be substantially under the control of a computer system, and in such a case, it is another example of automated completion system or a part of a closed-loop completion system to complete oil and gas wells.

The above described "landing means" can be used for yet another purpose. This "landing means" can also be used during the one-trip-down-drilling and completion of wellbores in the following manner. First, a standard rotary drill bit is attached to the "landing means". However, the attachment for the drill bit and the landing means are designed and constructed so that a ball plug is pumped down from the surface to release the rotary drill bit from the landing means. There are many examples of such release devices used in the industry, and no further description shall be provided herein in the interests of brevity. For example, relatively recent references to the use of a pump-down plugs, ball plugs, and the like include the following: (a) U.S. Patent No. 5,833,002, that issued on November 10, 1998, having the inventor of Michael Holcombe, that is entitled "Remote Control Plug-Dropping Head", an entire copy of which is incorporated herein by reference; and (b) U.S. Patent No. 5,890,537 that issued on April 6, 1999, having the inventors of Lavaure et. al., that is entitled "Wiper Plug Launching System for Cementing Casing with Liners", an entire copy of which is incorporated herein by reference. After the release of the standard drill bit from the landing means,

a retrievable drill bit and underreamer can thereafter be conveyed downhole from the surface through the drill string (or the casing string, as the case may be) and suitably attached to this landing means. Therefore, during the one-trip-down-drilling and completion of a wellbore, the following steps may be taken: (a) attach a standard rotary drill bit to the landing means having a releasing mechanism actuated by a releasing means, such as a pump down ball; (b) drill as far as possible with standard rotary drill bit attached to landing means; (c) if the standard rotary drill bit becomes dull, drill a sidetrack hole perhaps 50 feet or so into formation; (d) pump down the releasing means, such as a pump down ball, to release the standard rotary drill bit from the landing means and abandon the then dull standard rotary drill bit in the sidetrack hole; (e) pull up on the drill string or casing string as the case may be; (f) install a sharp retrievable drill bit and underreamer as desired by attaching them to the landing means; and (f) resume drilling the borehole in the direction desired. This method has the best of both worlds. On the one-hand, if the standard rotary drill bit remains sharp enough to reach final depth, that is the optimum outcome. On the other-hand, if the standard rotary drill bit dulls prematurely, then using the above defined "Sidetrack Drill Bit Replacement Procedure" in elements (a) through (f) allows for the efficient installation of a sharp drill bit on the end of the drill string or casing string, as the case may be. The landing means may also be made a part of a Smart Drilling and Completion Sub. If a Retrievable Instrumentation Package is present in the drilling apparatus, for example within a Smart Drilling and Completion Sub, then the above steps need to be modified to suitably remove the Retrievable Instrumentation Package before step (d) and then re-install the Retrievable Instrumentation Package before step (f).

However, such changes are minor variations on the preferred embodiments herein described.

To briefly review the above, many descriptions of closed-loop completion systems have been described. One preferred embodiment of a closed-loop completion system uses methods of causing movement of shuttle means having lateral sealing means within a "pipe means" disposed within a wellbore that includes at least the step of pumping a volume of fluid from a first side of the shuttle means within the pipe means to a second side of the shuttle means within the pipe means, where the shuttle means has an internal pump means. Pumping fluid from one side to the other of the smart shuttle means causes it to move "downward" into the pipe means, or "upward" out of the pipe means, depending on the direction of the fluid being pumped. The pumping of this fluid causes the smart shuttle means to move, translate, change place, change position, advance into the pipe means, or come out of the pipe means, as the case may be, and may be used in other types of pipes.

In Figure 18B, elements 2, 30, 32, 34, and 36 have been separately identified in relation to Figures 1, 3 and 4.

In **Figure 18B**, the Latching Float Collar Valve Assembly 21 is related to the Latching Float Collar Valve Assembly 20 in Figures 1, 3 and 4. However, in one preferred embodiment, the Latching Float Collar Valve Assembly 21 herein has different dimensions for the unique purposes and applications herein described.

In Figure 18B, the Upper Seal 23 is related to the Upper Seal 22 of the Latching Float Collar Valve Assembly in

Figures 1, 3 and 4. However, the Upper Seal 23 is different in view of the different geometries of pipes described below.

In Figure 18B, the Latch Recession 25 is related to the Latch Recession 24 Figures 1, 3 and 4. The depth and length of the Latch Recession 25 is different in view of the different geometries of the pipes described below.

In Figure 18B, the Latch 27 is related to Latch 26 of the Latching Float Collar Valve Assembly in Figures 1, 3 and 4. However, the Latch 27 must mate to the new dimensions of the Latch Recession 25.

In Figure 18B, the Latching Spring 29 is related to the Latching Spring 28 in Figures 1, 3 and 4. However, the Latching Spring 29 must have a different geometry in view of the different Latch Recession 25 and the different Latch 27 in Figure 18B.

Figure 18B shows a "pipe means" 676 deployed in the wellbore. The "pipe means" 676 can also be called simply a pipe for the purposes herein. The pipe 676 has no drill bit attached to the end of the pipe. The "pipe means" is a pipe deployed in the wellbore for any purpose and may be a pipe made of any material, which includes the following examples of such "pipe means": a metallic pipe; a casing; a casing string; a casing string with any retrievable drill bit removed from the wellbore; a casing string with any drilling apparatus removed from the wellbore; a casing string with any electrically operated drilling apparatus retrieved from the wellbore; a casing string with any bicenter bit removed from the wellbore; a steel pipe; an expandable pipe; an expandable pipe made from any material; an expandable metallic pipe; an expandable metallic pipe with any retrievable drill bit

removed from the wellbore; an expandable metallic pipe with any drilling apparatus removed from the wellbore; an expandable metallic pipe with any electrically operated drilling apparatus retrieved from the wellbore; an expandable metallic pipe with any bicenter bit removed from the wellbore; a plastic pipe; a fiberglass pipe; a composite pipe; a composite pipe made from any material; a composite pipe that encapsulates insulated electrical wires carrying electricity and or electrical data signals; a composite pipe that encapsulates insulated electrical wires and at least one optical fiber; any composite pipe that encapsulates insulated wires carrying electricity and/or any tubes containing hydraulic fluid; any composite pipe that encapsulates insulated wires carrying electricity and/or any tubes containing hydraulic fluid and at least one optical fiber; a composite pipe with any retrievable drill bit removed from the wellbore; a composite pipe with any drilling apparatus removed from the wellbore; a composite pipe with any electrically operated drilling apparatus retrieved from the wellbore; a composite pipe with any bicenter bit removed from the wellbore; a drill pipe; a drill string; a drill string with any retrievable drill bit removed from the wellbore; a drill string with any drilling apparatus removed from the wellbore; a drill string with any electrically operated drilling apparatus retrieved from the wellbore; a drill string with any bicenter bit removed from the wellbore; a tubing; a tubing string; a coiled tubing; a coiled tubing left in place after any mud-motor drilling apparatus has been removed from the wellbore; a coiled tubing left in place after any electrically operated drilling apparatus has been retrieved from the wellbore; a liner; a liner string; a liner made from any material; a liner with any retrievable drill bit removed from the wellbore; a liner with any liner drilling apparatus removed from the wellbore; a liner with

any electrically operated drilling apparatus retrieved from the liner; a liner with any bicenter bit removed from the wellbore; any pipe made of any material with any type of drilling apparatus removed from the pipe; any pipe made of any material with any type of drilling apparatus removed from the pipe; or any pipe means to convey oil and gas to the surface for oil and gas production.

In Figure 18B, pipe means 676 is joined at region 678 to lower pipe section 680. Region 678 could provide matching overlapping threads, welded pipes, or any conceivable means to join the "pipe means" 676 to the lower pipe section 680. The bottom end of the lower pipe section 680 is shown as element 681. The portion of the lower pipe section 680 that mates to the Upper Seal 23 is labeled with legend 682, which may have a suitable radius of curvature, or other suitable shape, to assist the Upper Seal 23 to make good hydraulic contact. The interior of lower pipe section is labeled with element 683. Lower pipe section 680 has Latch Recession 25. The Latching Float Collar Valve Assembly is generally designated as element 21 in Figure 18B, which is also be called the following for the purposes described here: a one-way cement valve; a one-way valve; a pump-down one-way cement valve; a pump-down one-way valve; a pump-down one-way cement valve means; a pump-down one-way valve means; a pump-down latching one-way cement valve means; and a pump-down latching one-way valve means. Particular varieties of one-way valve means include one-way float valves so named because of the Float 32 shown in Figures 1, 3, 4, 18B, and 18C. Those varieties of one-way valve means having float valves can be called a "pump-down one-way float valve"; or a "pump-down float valve"; or a "pump-down one-way cement float valve"; or a "pump-down cement float valve"; or a "pump-down float valve means"; or a "pump-down cement float valve

means"; or simply a "cement float valve". Other one-way valve means include various different types of flapper devices to replace the float shown in Figures 1, 4, 18B and 18C. All of these different devices may be collectively called a one-way cement valve means or by other similar names defined above including a latching float collar valve assembly.

The particular variety of a pump-down one-way cement valve shown in Figure 18B latches into place in Latch Recession 25. There are many variations possible for such "stops" for the pump-down one-way cement valve, including element 674 in Figure 18A that can be used as a "stop" for a pump-down one-way valve means following the retrieval of the retrievable drill bit as described above in relation to that Figure 18A.

In Figure 18B, the wall thickness of the "pipe means" 676 is designated by the legend "t1". The wall thickness of the lower pipe section 681 is designated by the legend "t2". The thickness remaining in the wall of the lower pipe section near the Latch Recession 25 is designated by the legend "t3". The portion of the lower pipe section 680 extending below the pipe joining region 678 to the beginning of region 682 having curvature has the wall thickness designated by the legend "t4".

Figure 18C also shows a "pipe means" 676 deployed in the well. In Figure 18C, pipe means 676 is joined at region 678 to lower pipe section 680. As in the previous Figure 18B, region 678 could provide matching overlapping threads, welded pipes, or any conceivable means to join the "pipe means" 676 to the lower pipe section 680. The bottom

end of lower pipe section is shown as element 681. The interior of lower pipe section is labeled with element 683.

In Figure 18C, the wall thickness of the "pipe means" 676 is designated by the legend "t1". The wall thickness of the lower pipe section 681 is designated by the legend "t2". The thickness remaining in the wall of the lower pipe section near the Latch Recession 25 is designated by the legend "t3". The portion of the lower pipe section 680 extending below the pipe joining region 678 to the beginning of region 682 having curvature has the wall thickness designated by the legend "t4".

As shown in Figures 18B and 18C, the pipe means 676, the the lower pipe section 680, and the joining region 678 are identical for the purposes of discussions herein. As drawn, these are the same pipes in the wellbore.

Retrievable drill bit apparatus 684, also called a retractable drill bit apparatus, is disposed within lower pipe section 680. The retrievable drill bit 686, also called the retractable drill bit, is attached to the retrievable bit apparatus at location 688. The retrievable drill bit has pilot drill bit 702, and first undercutter 692, and second undercutter 694. The pilot bit may be any type of drill bit including a roller cone bit, a diamond bit, a drag bit, etc. which may be removed through the interior of the lower pipe section (when the first and second undercutters are retracted). Portions of such a retractable drill bit apparatus are generally described in U.S. Patent No. 5,197,553, an entire copy of which is incorporated herein by reference. The retrievable drill bit apparatus latch 695 latches into place within Latch Recession 25. The retrievable drill bit apparatus possesses a top retrieval sub

696 so that it can be retrieved by wireline or by drill pipe, or by other suitable means. The latching mechanism of the top retrieval sub 696 is analogous to the 'retrievable means 206 that allows a wireline conveyed device from the surface to "lock on" and retrieve the Retrievable Instrumentation Package', which is quoted from above in relation to Figure 7. The latching mechanism of the top retrieval sub 696 allows mud to flow through it that is analogous to mud passage 198 through the Retrievable Instrumentation Package 194 that is shown in Figure 7. In one preferred embodiment, the restriction of mud flowing through the top retrieval sub 696 provides sufficient force to pump the retrievable drill bit apparatus down into the well. In another preferred embodiment, the retrievable drill bit apparatus 684 is installed with the Smart Shuttle that is shown as numeral 306 in Figures 8, 9, and 10. As yet another embodiment of the invention, a seal 697 within the top retrieval sub 696 allows it to be pumped down with well fluid, which is ruptured with sufficient mud pressure after the retrievable drill bit apparatus 684 properly latches into place. Seal 697 within the top retrieval sub 696 is not shown in Figure 18C for the purposes of simplicity. Seal 697 functions similar to seal fragments 54 and 56 within element 62 in Figure 1 or to seal 130 in element 146 in Figure 4. Upper seal 698 of the retrievable drill bit apparatus is used to pump down the apparatus into place with well fluids and to prevent mud from flowing downward below the upper seal in the region between the inner portion of lower pipe section 680 and the outer portion of the retrievable drill bit apparatus (which region is designated by element 690 in Figure 18C). The portion of the lower pipe section 680 that mates to the upper seal 698 is labeled with legend 682, which may have a suitable radius of curvature, or other suitable shape, to assist the upper seal 698 of the retrievable drill bit apparatus to make a

good hydraulic seal. The outside diameter d1 of the retrievable drill bit apparatus 684 is designated by the legend d1 in Figure 18C.

The well is drilled and completed using the following procedure. In relation to Figure 18C, the retrievable drill bit apparatus 684 is pumped down through the interior of the pipe means 676 and into the interior of lower pipe section that is labeled with element 683. Drilling fluids, or drilling mud, is used to pump the retrievable drill bit apparatus into place until the retrievable drill bit apparatus latch 695 latches into place within Latch Recession 25. Using procedures described in U.S. Patent 5,197,553, and in other similar references described above, the undercutters 692 and 694 are then deployed into position. The pilot bit 702 is shown in Figure 18C. Then, the "pipe means" 676 is rotated from the surface to drill the wellbore. Other types of key-locking means that locks the retrievable drill bit apparatus into the lower pipe section 680 are not shown for simplicity. Mud is pumped down the interior of the "pipe means" and through the retrievable drill bit apparatus mud flow channel 700, through the mud channels in the pilot bit 702, and into the annulus of the borehole 704. The mud channels in the pilot bit are not shown in Figure 18C for the purposes of simplicity. After the desired depth is reached from the surface of the earth, then the retrievable drill bit apparatus is retrieved by wireline or by drill pipe means as described in U.S. Patent No. 5,197,553 and elsewhere.

Then using techniques described in relation to Figures 1, 3 and 4, then the one-way cement valve means 21 is installed into the interior of lower pipe section that is labeled with element 683. It is pumped down into the well with well fluids until the Latch 695 latches into Latch

Recession 25. Thereafter, various wiper plugs are pumped into the interior of the pipe means 676 as described in relation to Figures 1, 2, 3 and 4 to cement the well into place.

It is now appreciated that the dimensions of portions of the Latching Float Collar Valve Assembly 21, including the Upper Seal 23, the Latch Recession 25, the Latch 27, and the Latching Spring 29 are to be designed so that the outside diameter d1 of the retrievable drill bit apparatus 684 designated by the legend d1 in Figure 18C can be as large as possible. This outside diameter d1 needs to be as large as possible to provide the required strength and ruggedness of the retrievable drill bit apparatus 684. This outside diameter d1 also helps provide the necessary room and strength for the undercutters 692 and 694.

The retrievable drill bit apparatus 684 in Figure 18 may be replaced with any number of different retrievable drill bit apparatus including, but not limited, to: (a) a mud-motor retrievable drilling apparatus; (b) an electric motor retrievable drilling apparatus; and (c) any retrievable drilling apparatus of any type.

In the above discussion in this Section, a well fluid may include any of the following: water, mud, or cement. In the above discussion in this Section, the term "well fluid" may also be a "slurry material" defined earlier.

The pump-down one-way valve means may include the following: (a) any types of devices that latch into place near the end the a pipe; (b) any type of devices that "bottom out" against a stop near the end of a pipe; (c) any type of devices that have a "locking key-way"

near the end of a pipe; (d) any type of devices that have overpressure activated "locking dogs" that lock into place near the end of a pipe; (e) any type of pump-down one-way valve means attached to a wireline where sensors are used to sense the position, and to control, the one-way valve; (e) any type of pump-down one-way valve means attached to a coiled tubing; and (f) any type of pump-down one-way valve means attached to a coiled tubing having electrical conductors that are used to sense the position, and to control, the one-way valve.

Various preferred embodiments provide for an umbilical to be attached to a pump-down one-way valve means where the umbilical explicitly includes a wireline; a coiled tubing; a coiled tubing with wireline; one or more coiled tubings in one concentric assembly with at least one electrical conductor; one or more coiled tubings in one assembly that may be non-concentric; a composite tube; a composite tube with electrical wires in the wall of the composite tube; a composite tube with electrical wires in the wall of the composite tube and at least one optical fiber; a composite tube that is neutrally buoyant in any well fluid present; a composite tube with electrical wires in the wall of the composite tube that is neutrally buoyant in well fluids present; a composite tube with electrical wires in the composite tube and at least one optical fiber that is neutrally buoyant in any well fluids present.

In view of the above, one preferred embodiment of the invention is the method of drilling and completing a wellbore in a geological formation to produce hydrocarbons from a well comprising at least the following four steps: (a) drilling the well with a retrievable drill bit attached to a casing; (b) removing the retrievable drill bit from the casing;

(c) pumping down a one-way valve into the casing with a well fluid; and (d) using the one-way valve to cement the casing into the wellbore.

In view of the above, another preferred embodiment of the invention is the method of pumping down a one-way valve with a well fluid into a casing disposed in a wellbore penetrating a subterranean geological formation that is used to cement the casing into the wellbore as at least one step to complete the well to produce hydrocarbons from the well, whereby any retrievable drill bit attached to the casing to drill the well is removed from the casing prior to the step.

In view of the above, another preferred embodiment of the invention is the method of pumping down a one-way valve with well fluid into a pipe disposed in a wellbore penetrating a subterranean geological formation that is used to cement the pipe into the wellbore as at least one step to complete the well to produce hydrocarbons from the well, whereby the retrievable drill bit attached to the pipe to drill the well is removed from the pipe prior to the step, and whereby the pipe is selected from the group of "pipe means" listed above. Here, the well fluid may be drilling mud, cement, water or a "slurry material" which has been defined earlier.

In accordance with the above, a preferred embodiment of the invention is a method of one pass drilling from an offshore platform of a geological formation of interest to produce hydrocarbons comprising at least the following steps: (a) attaching a retrievable drill bit to a casing string located on an offshore platform; (b) drilling a borehole into the earth from the offshore platform to a geological formation of interest; (c) retrieving the retrievable drill

bit from the casing string; (d) providing a pathway for fluids to enter into the casing from the geological formation of interest; (e) completing the well adjacent to the formation of interest with at least one of cement, gravel, chemical ingredients, mud; and (f) passing the hydrocarbons through the casing to the surface of the earth. Such a method applies wherein the borehole is an extended reach wellbore and wherein the borehole is an extended reach lateral wellbore.

In accordance with the above, a preferred embodiment of the invention is a method of one pass drilling from an offshore platform of a geological formation of interest to produce hydrocarbons comprising at least the following steps: (a) attaching a retractable drill bit to a casing string located on an offshore platform; (b) drilling a borehole into the earth from the offshore platform to a geological formation of interest; (c) retrieving the retractable drill bit from the casing string; (d) providing a pathway for fluids to enter into the casing from the geological formation of interest; (e) completing the well adjacent to the formation of interest with at least one of cement, gravel, chemical ingredients, mud; and (f) passing the hydrocarbons through the casing to the surface of the earth. Such a method applies wherein the borehole is an extended reach wellbore and wherein the borehole is an extended reach lateral wellbore.

It should also be noted that various preferred embodiments have been described which pertain to offshore platforms. However, other preferred embodiments of the invention are used to perform casing drilling from a Floating, Processing Storage and Offloading ("FPSO") Facility; from a Drill Ship; from a Tension Leg Platform

("TLP"); from a Semisubmersible Vessel; and from any other means that may be used to drill boreholes into the earth from any structure located in a body of water which has a portion above the water line (surface of the ocean, surface of an inland sea, the surface of a lake, etc.) Therefore, methods and apparatus described in this paragraph, and in relation to Figures 5, 6, and 18, are preferred embodiments of "offshore casing drilling means".

In view of the above, yet another preferred embodiment of the invention is the method of pumping down a one-way valve into a pipe with a fluid that is used as a step to cement the pipe into a wellbore in a geological formation within the earth.

In view of the above, yet another preferred embodiment of the invention is the method of pumping down a cement float valve into a casing with a fluid that is used as a step to cement the casing into a wellbore in a geological formation within the earth.

In view of the above, the phrases "one-way valve", "cement float valve", and "one-way cement valve means" may be used interchangeably.

While the above description contains many specificities, these should not be construed as limitations on the scope of the invention, but rather as exemplification of preferred embodiments thereto. As have been briefly described, there are many possible variations. Accordingly, the scope of the invention should be determined not only by the embodiments illustrated, but by the appended claims and their legal equivalents.